The Knowledge Structure in Amarakośa

Doctor of Philosophy
in
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Chapter 1

Overview

Amarakośa is the most celebrated and authoritative ancient thesaurus of Sanskrit. It is one of the books which an Indian child learning through Indian traditional educational system memorizes as early as his first year of formal learning. Though it appears as a linear list of words, close inspection of it shows a rich organisation of words expressing various relations a word bears with other words. Thus when a child studies Amarakośa further, the linear list of words unfolds into a knowledge web. Here we describe our effort to make the implicit knowledge in Amarakośa explicit. A model for storing such structure is discussed and a web tool is described that answers the queries by reconstructing the links among words from the structured tables dynamically.

The second chapter provides a brief introduction about *Amarakośa*, its author *Amarasiṁha*, the textual organization of *Amarakośa*, and the statistics of each *kāṇḍa*. A brief summary of important commentaries on *Amarakośa* in Indian as well as foreign languages is provided.

Chapter three gives a brief introduction about lexicon. Three kinds of lexicons viz. Sanskrit kośas, modern Sanskrit lexicons and electronic lexicons are briefed here. The purpose of this chapter is to know the modern trends in e-lexicon building. An important e-lexicon 'WordNet' is discussed in order to understand various kinds of relations it uses to connect the words.

Amarakośa, also known as *nāmaliṅgānuśāsana* is primarily considered to be an authoritative tool for knowing the gender of a word and its synonymous

words. In the fourth chapter we discuss the techniques used by *Amarasiṁha* for indicating the gender and number. *Amarasiṁha* provides some meta rules in the introductory part of the *Amarakośa* from the third to fifth *śloka*s. These techniques are discussed with examples. The other meaning making keys viz. *tu* and *atha* are also noted. While assigning the genders to various words in *Amarakośa* following *Amarakośa*s meta language, we also noticed some deviations from the Monier William's dictionary. We carried out the gender comparison with Monier William's Dictionary and *Amarakośa*. Finally, the primary purpose of *Amarakośa* being to provide synonymous words, we also studied the "polysemy distribution in *Amarakośa*".

The next chapter is named as "Knowledge Structure in Amarakośa". In this chapter we show, through examples, how the organisation of synsets within a varga leads to a semantic web relating various concepts. We take three examples from three different *varga*s, representing totally different concepts, to show various kinds of relations involved in the consecutive synsets viz. *Viṣṇuḥ, Samayaḥ* and *Kṣatriyaḥ*. The detailed study also shows that some semantic relations among the consecutive synsets are more frequent. The frequent implicit relations are : is a part of (avayavāvayavī), is a kind of (parāparājāti), child-parent relation (janyajanakabhāva), husband-wife relation (patipatnībhāva), master-possession relation (svasvāmibhāva) and livelihood (ājīvikā).

The sixth chapter, "Ontological Representation scheme for *Amarakośa*" deals with the ontological representation of each words in *Amarakośa*. The different divisions of Ontology such as Western ontology, Indian ontology and upper level ontologies are briefed. We base our ontological classification on *Vaiśeṣika* ontology. Wherever necessary we also deviate a little from the *Vaiśeṣiaka* ontology incorporating classification from other Indian philosophical schools. In addition to the ontological classification (*jāti*) which shows single inheritance, to capture the imposed or acquired properties by various objects, we resort to *upādhi*s as well in order to mark other properties associated with the object. *Jāti* follows the conditions imposed by *Jātibādhakās* while *upādhi* does not.

We name the web application showing these relations and ontological representation as *Amarakośajñānajālam*. The structure of this system is discussed in the seventh chapter. Two major parts of this system are

structured lexicon and tables marking various relations. The structured lexicon have five parts viz. Stem, Amarakośa index, Liṅgam (gender), Vargaḥ and Head Word. We then discuss the creations of tables marking various relations. This is followed by the representation of ontological relations in the data. Finally we brief on the web application with a choice of 'Apache' server and 'PERL' as a scripting language for CGI.

The other task which we carried out is the synset comparisons between *Amarakośa* and Hindi WordNet in order to know how much can we borrow from the existing Hindi WordNet into Sanskrit WordNet based on *Amarakośa* words there by avoiding duplication of efforts. It is discussed in the eighth chapter. We first give the structure of Hindi WordNet database, and the structure of *Amarakośa* synset. Different kinds of the mismatches and the causes of the difference in the unmatched synsets are discussed here. Different kinds of problems viz. conceptual problems, extended usage, shrink usage etc. are discussed here and also given some suggestions for Hindi WordNet.

Some pointers to how Amarakośajñānajāla can be used as a model for other kośas and how it can be used for a variety of Natural Language Processing tasks including information retrieval, semantic tagging, disambiguation, ontologies etc. are provided in the concluding chapter.

Our main contribution may be summarized as :-

- to make the implicit relations among various synonymous words in *Amarakośa* explicit,
- to carry out this work independently without getting influenced by the existing electronic lexicons,

  and finally

- to provide a computational model to build similar lexica using other Sanskrit and Indian language kośas.

Chapter 2

Introduction

Study of any language involves mastering its vocabulary, grammar and literature. Since mastering the vocabulary is a hard task, in mother tongue our vocabulary is enriched by practice. But for learning other languages some means of remembering is required, either by studying the literature of that language or versification of words with their meaning. Versification has been successfully accomplished in Sanskrit. Sanskrit scholars quote lexicons such as *Amarakośa, Vaijayantī* etc. while commenting on any Sanskrit text as authorities for different shades of meaning of such words. The Sanskrit lexicon most widely used by all is Amara's *Nāmaliṅgānuśāsanaṃ.* Many excellent scholars such as *Kṣīrasvāmī, Bhānujidīkṣita* and so on have commented upon it.

2.1 Amarakośa

The *nighaṇṭu* is the oldest lexicographical literature in Sanskrit which is mainly intended to help the interpretation of Vedic texts. The *nighaṇṭus* confined themselves to the Vedas which contained not only nominal forms but also verbal ones whereas the kośas dealt with words in classical literature and restricted themselves to the nominal forms and the indeclinables.

The *Nāmaliṅgānuśāsana*, the most celebrated and authoritative ancient thesaurus of Sanskrit, authored by *Amarasiṁha* is considered as an essential requisite for a Sanskrit scholar. It is concise, comprehensive and most

profusely used lexicon in Sanskrit.

The *Amarakośa* (dictionary of *Amara*) or *Nāmaliṅgānuśāsana* is a thesaurus of Sanskrit written by *Amarasiṁha* . The word amara means "immortal" and kośa means "treasure, casket, pail, collection, dictionary". Thus the word *Amarakośa* literally means "Immortal Treasure". Its alternative name *nāmaliṅgānuśāsana* literally means "instructions for deciding the genders of nouns. It is also known as *Trikāṇḍa* as it contains three kaṇḍas. *Amarakośa* is also known as *paryāyakośa* or a dictionary of synonymous words.

Amarakośa is prepared most scientifically and is comprehensive in all respects. Sanskrit kośas were mainly of two types. Some of the kośas dealt with nominal words while others were developed for explaining the gender. The former is known as *Nāmamātratantra* and the latter is *Liṅgamātratantra*. But *Amarasiṁha* combined both the styles and methods in his dictionary (Encyclopedia of Indian Literature Vol.2 page 1036). *Amarasiṁha* mentions his work as *Nāmaliṅgānuśāsana* in this śloka :-

समाहृत्यान्यतन्त्राणि संक्षिप्तैः प्रति संस्कृतैः।
सम्पूर्णमुच्यते वर्गैर्नामलिङ्गानुशासनम्।। 1.1.2 a.k

2.2 Amarasiṁha - the author of Amarakośa

Amarasiṁha , the renowned scholar, is the author of the ancient lexicon *Amarakośa*, which is clear from the colophon :-

॥ इत्यमरसिंहकृतौ नामलिङ्गानुशासने स्वरादिकाण्डः प्रथमः साङ्ग एव समर्थितः ॥

This is the only information about *Amarasiṁha* that we get from *Amarakośa*. He didn't mention any information about him anywhere in *Amarakośa*.

Amarasiṁha was considered as a well-known poet. The following śloka reveals his poetic proficiency.

प्रयोगव्युत्पत्तौ प्रतिपदविशेषार्थकथने
प्रसत्तौ गांभीर्ये रसवती च काव्यार्थरचने।
अगम्यायामन्यैर्दिशिपरिणतेरर्थवर्चसो–

र्मतम् चेदस्माकं कविरमरसिंहो विजयते॥[1]

It describes the usefulness and derivations of a word. The word 'kavi' in the fourth *pāda* reveals his fame as a poet. The construction of the first śloka of *Amarakośa* shows his excellency in poetry[2].

Mallinātha calls *Amarasiṁha* 'kavi' in the last verse of his commentary on *Amarakośa.* He also says that the immortality of *nāmaliṅgānuśāsana* is assured as this faultless work will last as long as the moon and the stars shine in the sky :-

कवेरमरसिंहस्य कृतिरेषा सुनिर्मला।
आचन्द्रतारकं स्थेयान्नामलिङ्गानुशासनम्॥[3]

Amarasiṁha was a good grammarian. He is counted as one of the eight grammarians. It was stated in the *Kavikaṇṭhābharaṇa.*

इन्द्रश्चन्द्रः काशकृत्स्नापिशली शाकटायनः।
पाणिन्यमरजैनेन्द्रः जयन्त्यष्टौ हि शाब्दिकाः॥[4]

There is a popular humorous saying that *Amarasiṁha* robbed all the authoritative interpretations of *Patañjali*'s *Mahābhāṣya.*

अमरसिंहो हि पापीयान् सर्वम् भाष्यमचूचुरत्।[5]

This shows the thorough mastery of *Amarasiṁha* in grammar.

Amarasiṁha was the son of *śabarasvāmi* and his mother was a śūdra lady.

ब्राह्मण्यामभवद्वराहमिहिरो ज्योतिर्विदामग्रणी
राजा भर्तृहरिश्च विक्रमनृपः क्षत्रात्मजायामभूत्।
वैश्यायां हरिचन्द्रवैद्यतिलको जातश्च शंकुः कृती
शूद्रायाममरः षडेव शबरस्वामिद्विजस्यात्मजाः॥[6]

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[1]Cited by T.C. Parameshvaran Moosat, 1959, p. 16

[2]यस्य ज्ञानदयासिन्धोरघातस्यानघागुणाः।
सेव्यतामक्षयो धीराः स श्रिये चामृताय च॥ (1.1.1 a.k.)

[3]Cited by A.A Ramanathan, 1971, p. XV

[4]Cited by N. P. Unni, 2008, p. IV

[5]Cited by N. P. Unni, 2008, p. V

[6]*Indian Catalogue*, Vol-6 p. 209, cited Kailash Candra Tripathi, 1984

Some scholars conclude that *Amarasiṁha* was a Buddhist. Following arguments help in arriving at this decision:

1. In the maṅgalaśloka

> यस्य ज्ञानदयासिन्धोरघातस्यानघागुणाः।
> सेव्यतामक्षयो धीराः स श्रिये चामृताय च॥ (1.1.1 a.k.)

the word *jñānadayāsindhuḥ* is very much suitable for *Buddha*.

2. He started the synonyms of *devatā* with the synonyms of *Buddha*. In *nānārthavarga* also *Buddha* is mentioned.

If these arguments are accepted, then the following is a counter argument for the above.

But the word *jñānadayāsindhuḥ* can keep as a simile of any God like *Viṣṇu* or *Śiva* or *Rāma* or *Kṛṣṇa*. If he was a Buddhist then he would have mentioned about *Bauddhasaṅghas*.

Some scholars opined that he was a follower of Jaina as *Amarasiṁha* mentioned *dharmarājau jinayamau* as the synonym of *Jaina*.

Nothing apart from his works is known with certainty about the religion of *Amarasiṁha* . He neither mentioned about *Buddhasaṅgha's* nor *jainasaṅgha's*. It clears that he did not belong to any of these two. The major part of his work discusses *varṇātmakavyavasthā* and *yajñasaṁsthā* and so on. It is very clear from the *Amarakośa* that he had deep knowledge of *śruti, Smṛti, Purāṇa, Itihāsa, Darśana* and so on.

Some sources indicate that *Amarasiṁha* was one of the "gem" in "Navaratnas" (nine gems) at the court of the king *Vikramāditya* of 7^{th} century, following *Kālidāsa*'s *Jyotirvidābharaṇam*.

> धन्वन्तरिः क्षपणकामरसिंहशंकु वेतालभट्टघटखर्परकालिदासाः।
> ख्यातो वराहमिहिरो नृपतेः सभायां रत्नानि वै वररुचिर्नवविक्रमस्य॥[7]

In the *Jyotirvidābharaṇam* the courtiers of *Vikramāditya* are :-

[7] Cited by N. P. Unni, 2008 p. IV

शङ्कुः सुवाग् वररुचिर्मणिरंशुदत्तो
जिष्णुस्त्रिलोचनहरी घटकर्पराख्यः।
अन्येऽपि सन्ति कवयोऽमरसिंहपूर्वा
यस्येह विक्रमनृपस्य सभासदोऽमी॥[8]

2.3 Textual Organization

The *Amarakośa* consists of verses which can be easily memorized. Most of the verses are written in Anuṣṭup meter. Even though it is a dictionary of synonymous words, a section called *nānārthavarga* has homonymous word too. The words in *nānārthavarga* are arranged as per the ending such as *kānta* (words ending with *'ka'*), *khānta* (words ending with *'kha'*) and so on.

Like other Sanskrit texts, *Amarakośa* also begins with a maṅgalaśloka.

यस्यज्ञानदयासिन्धोरघातस्यानघागुणाः।
सेव्यतामक्षयो धीराः स श्रिये चामृताय च।। 1.1.1 a.k

But he doesn't mention any God's name in his *maṅgalaśloka*. After *maṅgalaśloka* he brings up some special rules, which are metarules useful to understand the gender information of a word. (see the chapter "Gender information in Amarakośa").

Amarakośa is divided into three *kāṇḍa*s. *Kāṇḍa*s are further sub-divided into “vargas”. The first kāṇḍa has words pertaining to gods, heaven pañcamahābhūta (five basic elements) and abstract concepts such as dik (direction), kāla (time), vāk, etc. This chapter has ten “vargas”. The second kāṇḍa deals with the words denoting real physical objects such as earth, human beings, animals, plants etc. This chapter also has ten “vargas”. The third kāṇḍa has words related to grammar description of polysemous words and other miscellaneous words, and has five “vargas”.

2.3.1 Statistics

Statistics of *Amarakośa* is given below. Names of each varga, verse details in each varga, word number in each varga etc. are described.

[8] Cited by N. P. Unni, 2008 p. IV

Kāṇḍas

Prathamakāṇḍa, dvitīyakāṇḍa and tṛtīyakāṇḍa are the three *kāṇḍa*s.

Vargas

Vargas from each *kāṇḍa*s are named thus:

Prathamakāṇḍa

Svargavargaḥ (heaven)
Vyomavargaḥ (sky)
Digvargaḥ (direction)
Kālavargaḥ (time)
Dhīvargaḥ (cognition)
Śabdādivargaḥ (sound)
Nāṭyavargaḥ (drama)
Pātālabhogivargaḥ (nether world)
Narakavargaḥ (hell)
Vārivargaḥ (water)

Dvitīyakāṇḍa

Bhūmivargaḥ (earth)
Puravargaḥ (towns or Cities)
Śailavargaḥ (mountains)
Vanauṣadhivargaḥ (forests and medicines)
Siṃhādivargaḥ (lions and other animals)
Manuṣyavargaḥ (mankind)
Brahmavargaḥ (priest tribe)
Kṣatriyavargaḥ (military tribe)
Vaiśyavargaḥ (business tribe)
Śūdravargaḥ (mixed classes)

Tṛtīyakāṇḍa

Viśeṣyanighnavargaḥ (adjective)
Saṁkīrṇavargaḥ (miscellaneous)
Nānārthavargaḥ (polysemous)
Avyayavargaḥ (indeclinables)
Liṅgādisaṅgrahavargaḥ (gender)

Ślokas

ślokas in *Amarakośa* can normally be classified according to their nature, in three classes viz. *sāmānyaśloka, niyamaśloka* and *prakṣiptaśloka*. *Sāmānyaśloka*s are main verses, which contain synonymous words, and their meaning. *Niyamaśloka*s describe the meta language and *prakṣiptaśloka*s are the verses which are inserted later by others. To decide whether a śloka is *prakṣipta* or not, we follow the commentary by *Bhānuji Dīkṣita*, named *Sudhāvyākhyā* or *Rāmāśramī* edited by *Paṇḍit Śivadatta* in 1915. If the śloka is not there in these commentaries, it is considered as *prakṣiptaśloka*.

Verse details of each *kāṇḍa*s are given below in Table 2.1, Table 2.2 and Table 2.3.

Total *sāmānyaślokas* in *Amarakośa* are 1,492.1/2
Total *prakṣiptaślokas* are 58.1/2
Total *niyamaślokas* are 56.1/2
Total ślokas in *Amarakośa* are 1,607.1/2

Prathamakāṇḍa

Varga Name	Total śloka No.	Niyamaśloka	Prakṣiptaśloka
Svargavargaḥ	71	5	14
Vyomavargaḥ	1.1/2		2
Digvargaḥ	35		4
Kālavargaḥ	31		1.1/2
Dhīvargaḥ	17		1
Śabdādivargaḥ	25.1/2		2.1/2
Nāṭyavargaḥ	38		1.1/2
Pātālabhogivargaḥ	11		1.1/2
Narakavargaḥ	3.1/2		1/2
Vārivargaḥ	45	2	1/2

Table 2.1: Śloka statistics of *pradhamakāṇḍa*

Dvitīyakāṇḍa

Varga Name	Total śloka No.	Niyamaśloka	Prakṣiptaśloka
Bhūmivargaḥ	18	1	1
Puravargaḥ	20		1/2
śailavargaḥ	8		1/2
Vanauṣadhivargaḥ	169.1/2		
Siṁhādivargaḥ	43		4
Manuṣyavargaḥ	139.1/2		
Brahmavargaḥ	57.1/2		4.1/2
Kṣatriyavargaḥ	119.1/2		
Vaiśyavargaḥ	111.1/2		1
śūdravargaḥ	46.1/2	1	1/2

Table 2.2: Śloka statistics of *dvitīyakāṇḍa*

2.3.2 Words in Amarakośa

Amarakośa contains total 11580 content words from the three *kāṇḍa*s. Unique words from all *kāṇḍa*s are 9031. Content words are the words that are used to show the synonymous word or to define the synonymous words. Unique words are the total content words after removing the repetitions in the *kāṇḍa*s

Tṛtīyakāṇḍa

Varga Name	Total śloka No.	Niyamaśloka	Parakṣiptaśloka
Viśeṣyanighnavargaḥ	112.1/2		2
Saṅkīrṇavargaḥ	42.1/2		1/2
Nānārthavargaḥ	257	1	15
Avyayavargaḥ	23		
Liṅgādisaṅgrahavargaḥ	46	46	1/2

Table 2.3: Śloka statistics of *tṛtīyakāṇḍa*

Kāṇḍa	Total words	Content words
Prathamakāṇḍa	2,465	2,300
Dvitīyakāṇḍa	5,827	5,282
Tṛtīyakāṇḍa	3,288	2,271
Total	11,580	9,853

Table 2.4: Word statistics of *Amarakośa*

or across the *kāṇḍa*s. Word statistics according to each *kāṇḍa*s is given in Table 2.4.

2.3.3 The First Kāṇḍa

उक्तं स्वर्व्योमदिक्कालधीशब्दादि सनाट्यकम्।
पातालभोगि नरकं वारि चैषां च संगतम्।। 1.10.44 a.k.

The first kāṇḍa contains *svargavargaḥ* (heaven), *vyomavargaḥ* (sky), *digvargaḥ* (direction), *kālavargaḥ* (time), *dhīvargaḥ* (cognition), *śabdādivargaḥ* (sound), *nāṭyavargaḥ* (drama), *pātālabhogivargaḥ* (nether world), *narakavargaḥ* (hell), and *vārivargaḥ* (water).

Varga contents

- **Svargavargaḥ**
  Heaven, Gods, Demons, their arms, ornaments, symbols or vehicles, and other attributes, Fire, Air, Velocity, Eternity, etc.
- **Vyomavargaḥ**
  Sky

- **Digvargaḥ**
  Directions, Deities of the directions, elephants at the points, their female elephants, Cloud, thunder, lightning, rainbow, Rain, hail, rainy day, cloudy day, Moon, types of light, frost, Stars, Planets, sunset, dawn, sunlight, etc.

- **Kālavargaḥ**
  Time, day, night, variations of the moon, eclipse, second, hour, months, year, Weather, seasons, Happy, Sorrow, Soul, Mind, etc.

- **Dhīvargaḥ**
  Individuality, consciousness, knowledge, sense, organs, tastes, fragrance, colours, etc.

- **Śabdādivargaḥ**
  Sarasvatī, voice, word, Vedas, Vedāṅgas, stories, legends, sound, types of sounds, speech, musical sounds, song, ornament's sound, etc.

- **Nāṭyavargaḥ**
  Seven musical tones, Musical Instruments, dance, theatrical characters, sentiments, desire, affection, kindness, Festival etc.

- **Pātālabhogivargaḥ**
  Infernal region, hole, darkness, Snakes, kinds of serpent, parts of snake, etc.

- **Narakavargaḥ**
  Hell, various hells, departed souls, pain, etc.

- **Vārivargaḥ**
  Water, Ocean, wave, whirlpool, shore, channel, island, boat, voyage, pilot, deep, fish, fisherman, net, fish basket, hook, etc., types of fishes, Aquatic animals, crab, turtle, etc. Well, pond, types of ponds, River, Names of rivers, water plants, lotus, water lilly, etc. Parts of these plants etc.

2.3.4 The Second Kāṇḍa

वर्गाः पृथ्वीपुरक्ष्माभृद्वनौषधि मृगादिभिः।
नृब्रह्मक्षत्रविट् शूद्रैस्साङ्गोपांङ्गैरिहोदिता।। (2.1.1 a.k)

It is divided into ten Vargas or parts. They are *bhūmivargaḥ* (earth), *puravargaḥ* (towns or cities), *śailavargaḥ* (mountains), *vanauṣadhivargaḥ* (forests and medicines), *siṁhādivargaḥ* (lions and other animals), *manuṣyavargaḥ* (mankind), *brahmavargaḥ* (priest tribe), *kṣatriyavargaḥ* (military tribe), *vaiśyavargaḥ* (business tribe) and *śūdravargaḥ* (mixed class).

Varga contents

- **Bhūmivargaḥ**
  Earth, land, soil, clay, world, India, regions, types of lands, country, village, kingdom, hill, road,

- **Puravargaḥ**
  City, suburb, Market, fort, wall, house, kinds of houses, parts of house, house holdings, building land, etc.

- **Śailavargaḥ**
  Mountains, kinds of mountains, parts of mountains, caves, etc.

- **Vanauṣadhivargaḥ**
  Forest, garden, tree, parts of tree, flowers, fruits, leaf, shrub, creeper, names of trees, names of shrubs, names of creepers, names of grass, etc.

- **Siṁhādivargaḥ**
  Animals, lion, tiger, wolf, deer, kinds of deers, etc. Insects, bee, cricket, birds, hawk, skylark, crow, parrot, etc. parts of birds, wing, beak, etc.

- **Manuṣyavargaḥ**
  Man, woman, descriptions of woman, blood-relations like son, daughter, husband, wife etc., manhood, different stages of manhood, parts of our body, diseases such as cough, scab, etc., dress, ornaments, cloths, types of cloths, cosmetics, fragrant plants, sandal etc., hair decoration styles, daily usable things etc.

- **Brahmavargaḥ**
  Tribes, religious states, sacerdotal, scholars, characters and descriptions of priests, their occupations and observances, types of fires, sacrifice, its requisites, alms, worship, austerity, study, hypocrisy, marriage, human, pursuits and objects etc.

- **Kṣatriyavargaḥ**
  Military tribe, kings, ministers, officers, servants, enemies, allies, requisites of government, means of defence, and of success, revenue, foresight, insignia of royalty, army, elephants, parts and kind of elephants, horses, types of horses, vehicles, chariots, litters, warriors, arms and weapons, bow, arrow, javelin etc. war, slaughter, funeral, prison, life, etc.

- **Vaiśyavargaḥ**
  Third tribe, professions, husbandman, field, implements of husbandry, corn, pulse, oil-seeds, granary, kitchen, vessels, prepared food, dairy, cattle, traffic, weights and measures, commodities, etc.

- **Śūdravargaḥ**
  Fourth tribe, mixed classes, artisans, jugglers, dancers, musician, hunters, servants, barbarians, dogs, hogs, theft, nets, fops, loom, plot for burden, wrought leather, tools, art, images, wages, spirituous gaming, etc.

2.3.5 The Third Kāṇḍa

विशेष्यनिघ्नैस्सङ्कीर्णैर्नानार्थैरव्ययैरपि।
लिङ्गादिसङ्ग्रहैर्वर्गाः सामान्ये वर्गसंश्रयाः।। (3.1.1 a.k.)

Viśeṣyanighnavargaḥ (adjective), *saṅkīrṇavargaḥ* (miscellaneous), *nānārthavargaḥ* (polysemous), *avyayavargaḥ* (indeclinables), *liṅgādisaṅgrahavargaḥ* (gender). The third *kāṇḍa* contains adjectives, verbs, words related to prayer and business etc..

Varga contents

- **Viśeṣyanighnavargaḥ**
  Epithets of persons, Qualities of things, etc.

- **Saṅkīrṇavargaḥ**
  Miscellaneous

- **Nānārthavargaḥ**
  Homonymous and polysemous words

- **Avyayavargaḥ**
  Indeclinables

- **Liṅgādisaṅgrahavargaḥ**
  Genders, Masculine, Feminine, Neuter, Masculine and Feminine, Masculine and Neuter, Feminine and Neuter, Three genders, variations of gender.

2.4 Commentaries

Amarasiṁha 's lexicon is the oldest work of the kind now extant. It is of great interest to note that, it has been universally accepted as an authority by the *Brahmaṇ*s and the *Jainas* alike. The fact that it has been commented upon by Buddhists like *Subhūticandra*, by Jainas like *Āśādharapaṇḍita* and *Nācirāja*, and by Brahmans like *Kṣīrasvāmin, Mallīnātha* and *Appayyadīkṣita* testified to its usefulness to every class of Sanskrit students.

The commentaries on *Amarakośa* are available in almost all Indian languages. Translations of the *Amarakośa* into Chinese, Tibetan, Italian, French, Mongolia, Burmese etc. have been recently discovered. It is difficult to provide the exact number of commentaries on *Amarakośa*, as many of them are not available. In the world of Sanskrit literature a separate section is dedicated to the study of *Amarakośa* such as commentaries in Sanskrit and other languages, translations in other languages, other kośas on the basis of *Amarakośa*, etc. M.M Patkar in his book "History of Sanskrit Lexicography" mentions nearly 60 commentaries[9] on *Amarakośa* and also he tells that "Dr. Aufrecht records not less than forty commentaries on it in his "Catalogus Catalogorum"[10].

2.4.1 Amarakośa Translations in Foreign Languages

Chinese translation of *Amarakośa* is written by *Guṇarata* in 6^{th} Century A.D. The Italian translation of *Amarakośa* is published in 1798. French translation by *ALA Loiseleur-Deslongchamps* is published at Paris in 1839-1845. Tibetan translation of *Amarakośa* was done by *Kīrticandra* and

[9] M.M Patkar, 1981, p.172-174
[10] M.M Patkar, 1981, p.19

Grags-pargyal-mthsan of *Yar-luṅs* at *Yam-bu*, the ancient capital of Nepal[11], and it is published in 1912.[12]

Burmese *Amarakośa* was written (calligraphed) in 1938 by *Guṇālaṅkāra* at the *Shwegu Hall*. Its photo-mechanical reprint is done by *Lokesh Chandra*, son of the most famous lexicographer *Raghu Vīra*. He mentioned in the introduction of his book that his father has collected Amarakośa in different languages of Asia. From them he reproduced the Tibetan rendering of *Si-Tu* the well-known grammarian of the seventeenth century[13].

2.4.2 Sanskrit Commentaries on Amarakośa

Several well-versed Sanskrit commentaries emerged on *Amarakośa*. Some of these commentaries are commented from some special point of view. E.g. *Vyākhyāsudhā* is commented on grammatical point of view. *Ṭīkāsarvasvam* gives more elaborated grammatical details than *Vyākhyāsudhā*. Details of some famous commentaries on *Amarakośa* are given below.

Rāmāśramī or Vyākhyāsudhā

Vyākhyāsudhā or *Rāmāśramī* is a commentary of *Amarakośa* written by *Bhānuji Dīkṣita*, son of the celebrated grammarian *Bhaṭṭoji Dīkṣita*. It is also known as *Bhānujibhaṭṭīyam* in the name of the author. It is a well known and most celebrated commentary of *Amarakośa*. The *maṅgalaśloka* of *Sudhāvyākhyā* itself says that *Bhaṭṭoji Dīkṣita* is his teacher and he is going to write this commentary on the basis of the opinions of *Pāṇini, Kātyāyana* and *Patañjali* the *Munitraya* of Sanskrit grammar. The śloka is -

> वल्लवीवल्लभम् नत्वा गुरुं(गिरं) भट्टोजिदीक्षितम्।
> आ(अ)मरे विदधे व्याख्यां मुनित्रयमतानुगाम्।। (1 v.s)

The colophon of *Sudhā* says that *Bhānuji Dīkṣita* had written this book with the desire of *Kīrtisiṁhadeva*, ruler of *mahīdhara* and the prince of *Vaghela* family.

[11]Claus Vogel, 1979, p.312
[12]A.A Ramanathan, 1971, Introduction, p.xvi
[13]Lokesh Chandra, 1984

इति श्रीवघेलवंशोद्भवश्रीमहीधरविषयाधिपश्रीकीर्तिसिंहदेवाज्ञया
श्रीभट्टोजिदीक्षितात्मजश्रीभानुजीदीक्षितविरचितायाममरटीकायां
व्याख्यासुधाख्यायां तृतीयः काण्डः
समाप्तिमगात्।

It is also clear that *Bhānuji Dīkṣita* was the son of *Bhaṭṭoji Dīkṣita* the well-known grammarian. *Sudhā* itself shows his grammatical scholarship as he includes the root of the words, its *gaṇa, padī* like *ātmanepadī* or *parasmaipadī* etc. And it's *iṭ vyavasthā* like *seṭ, aniṭ* or *veṭ* and the suffix, it's Pāṇinīya sūtra, sutra number according to *Aṣṭādhyāyī*, the *vigrahavākya* of the word, etc.. He also makes lexicological references like *Medinīkośa, Trikāṇḍaśeṣa, viśvakośa* etc. Some times *Bhānuji Dīkṣita* includes the local name of the word also eg. *'jūhī' iti khyātāyāḥ, 'dopahariyā' iti khyātasya* etc. We can feel that *Bhānuji Dīkṣita*'s deep grammatical knowledge and the familiarity with other kośa's which were available at that time through the study of *Sudhāvyakhyā*.

For our work, we relied on this work a lot and in case of conflict we resorted to this commentary.

Amarakośodghāṭana

It is a commentary on *Amarakośa* written by *Kṣīrasvāmin. Nāmaparāyaṇa* or *amarakośodghaṭṭana* are the other names of this commentary. It is a very old commentary which is available now.

Ṭīkāsarvasvam

It is also a well-known commentary on *Amarakośa*, written by *Vandyaghaṭīya Sarvānanda*, a Bengali scholar. Following is the beginning śloka of this commentary.

> अथ टीकासर्वस्वम् दशटीकावित् करोत्यमरकोशे।
> श्रीमत्सर्वानन्दो वन्द्यघटीयार्तिहरपुत्रः॥

It states that, at the time of *Sarvānanda*, ten commentaries existed and studied by the commentators. As the commentator was not satisfied with any of these ten, he was forced to write a new commentary. The ending verses of the commentary :-

त्रीणि व्याकरणान्यधीत्य सकलं साहित्यमालोक्य च
प्राज्ञाध्यापकभाषितानि हृदये न्यस्याकृतेदम् स हि।
प्राज्ञेनानु सनातनेन बहुशः प्रत्यक्षरम् शोधितं
जिज्ञासा यदि शब्दवर्त्मनि तदा चैतत् समालोक्यताम्।।

With these verses he states the effort he had taken to write this commentary. The three grammarians referred by him are *Pāṇini, Kātyāyana* and *Patañjali.* He refers poets like *Kālidāsa, Bhāsa, Bāṇa, Māgha, Bhavabhūti, Murāri, Viśākhadatta, Vyāsa, Vālmīki* etc. We can feel his knowledge in grammar and literature and critical thoughts of the writer through the study of this commentary.

Amarapadapārijāta

Amarapadapārijāta the commentary of *Amarakośa* written by *Mallinātha*, is the commentator of *pañcamahākāvya*'s. He belongs to the Andhra country, as testified by the usages of Telugu equivalents in his commentary. His Father was *Nṛsiṁhasūrin*, and he is from the family of *Bollāṭinmi.*

बोल्लाटिन्मिनृसिंहसूरितनयः श्रीमल्लिनाथो..........।[14]

Mallinātha gives Telugu equivalent to almost all words in his commentary. He uses lots of citations also. Some authors mentioned that some of the citations are not traceable in the Catalogues Catalogorum also. He referred nearly 200 books in his work. The highest citation in the first two *kāṇḍa*s are from *Vaijayantikośa* of *Yādavaprakāśa.* He gives nearly 213 citations from this book. *Mallinātha*'s knowledge of grammar is very deep, and also it enables him to point out some points which were missed by many other commentators. The commentary *Amarapadapārijāta* of *Mallinātha* is very rich in case of word knowledge.

Amarapadavivṛti

Amarapadavivṛti is the commentary written by *Liṅgayyasūrin.* He is also known as *Liṅga* or *Liṅgabhaṭṭa* and his work is known as *Liṅgabhaṭṭīyam.* Like *Mallinātha* he also belonged to Andhra Pradesh. According to the colophons of *Amarapadavivṛti* his father's name is *Kāmaya Bhaṭṭa.*

[14] A. A. Ramanathan, 1971, p. xlvi

Liṅgayyasūrin speaks respectfully about *Kṣīrasvāmin* in the introductory verses of his commentary. He carefully memorized *Amarakośodghāḍanam* before writing his commentary. The verse is -

> पदवाक्यप्रमाणज्ञैः क्षीरस्वाम्यादिसूरिभिः।
> कृतान् ग्रन्थान् समालोच्य बालानां सुखबुद्धये॥

Liṅgayyasūrin explains the derivations and meanings of amara-words. He also gives the Telugu equivalent words in his commentary. His commentary was well received all along, especially in the southern region of India.

Amarapadaviveka

Amarapadaviveka is written by *Maheśvara.* It is also well-known in the name of the commentator *Maheśvara* as *Maheśvaratīkā.* He was the native of Maharashtra as is obvious from his use of Marathi words to explain the Amara words. He didn't mention any information about him anywhere in his book. *Amarapadaviveka* is a good and famous commentary on *Amarakośa.*

Padacandrikā

Padacandrikā is authored by *Rāyamukuṭa* whose surname is *Bṛhaspatiḥ.* He belongs to Bangala. He mentioned around 16 earlier commentators in his work that were available at his time and he repeatedly referred to some of these commentaries. According to H.T Colebrooke[15] those commentators are :- *Kṣīrasvāmin, Subhūti, Hāṭṭa Candra, Kaliṅga, Koṅkaṭa, Sarvadhara, Govardhana, Drāviḍa, Bhojarāja, Rājadeva. (Ṭīkāsarvasva, Vyākhyāmṛta, Mādhavī, Madhumādhavī, Abhinanda, Sarvānanda* - These are commentaries). *Padacandrikā* is one of the full commentary on *Amarakośa.*

These are some other well-known commentaries on *Amarakośa.*

Budhamanoramā by *Vedāntimahādeva*, *Amarapīyūṣa* by *Rāmakṛṣṇadīkṣita*, *Amaracandrikā* by *Paramānandamaidhila*, *Amarapadamukura* by *Raṅgācārya*, *Amarakośakaumudī* by *Nārāyaṇa Śarman*, *Amarapañcikā* by *Nārāyaṇa*, *Kāmadhenu* by *Subhūticandra*, *Kriyākalpa* by *Āśādhara*,

[15] Kosha or Dictionary of the sungskrita language by Umura singha with an English interpretations and annotations, Preface, vii.

Gurubālaprabodhikā by *Veṁkaṭeśvarayajvan*, *Trikāṇḍacintāmaṇi* by *Raghunādhacakravartin*, *Trikāṇḍaviveka* by *Rāmanādhavidyāvācaspati*, *Padamañjarī* by *Rāmeśvara Śarman*, *Padārthakaumudī* by *Nārāyaṇa Cakravarttin*, *Bhāvinī* by *Bhavanadāsa*, *Mugdabodhinī* by *Bhaṭṭasena*, *Liṅgabhaṭṭīya* by *Liṅgabhaṭṭa*, *Subodhinī* by *Jātānu Dīkṣita*

2.4.3 Other Indian Language Commentaries

Almost in all Indian languages, the commentaries on *Amarakośa* are available. These are of different types, some are the translations of some famous Sanskrit commentaries, some are Indian language commentaries based on other Sanskrit commentaries.

Malayalam commentaries

Pārameśvarīyam

Parameśvaran mūssat, the writer of the Malayalam commentary of *Amarakośa* named *Pārameśvarīyam*, has written three more Malayalam commentaries for *Amarakośa*. He is a good critique of *Amarakośa*. He followed *Bhānujidīkṣita* in his commentaries, but some times he also criticized *Bhānujidīkṣita*.

Pārameśvarīyam is the most popular and famous commentary of *Amarakośa* in Malayalam. It has rich grammatical properties. For each word he provides these properties, it's endings, gender, case, number, explanation in Malayalam, another readings (*pāṭhāntara*) and also quotes other lexicons and books as reference.

Triveṇī

Parameśvaran mūssat's another commentary for *Amarakośa* known as *Triveṇī* is also a famous Malayalam commentary. Like *Pārameśvarīyam* this is not a deep commentary. In this he explains only the word's meaning in Malayalam and some times in English also. This commentary is very useful for a person who is in search of some general information on *Amarakośa*. *Saṁkṣiptapārameśvarī* and *Padārthadīpikāvyākhyā* are the other *Amarakośa* commentaries of *Parameśvaran mūssat*

Bālapriyā is also a famous commentary on *Amarakośa* in Malayalam written by *Kaikkulaṅgara rāma vārier*. He himself was a teacher, so he created this work for the easy understanding of students.

Chapter 3

Lexicon

The history of lexicon begins from the vedic period itself. The very first lexicon is *Yāska*'s *Nighaṇṭu*, and it is the only lexicon which is available now for vedic words. According to the derivation of the word *Nighaṇṭu*, given by *Yāska* in his *Nirukta* - the *Nighaṇṭu* comprises of a list of vedic words[1].

Sāyaṇācārya in his *Ṛgvedabhāṣyopakrama*, define *Nighaṇṭu* as, "a book where the same meaning -synonymous- words are considered as a group". He refers to ten *Nighaṇṭu*s[2]. Now a days the term *Nighaṇṭu* is being used in the sense of "dictionary" in many modern Indian languages. *Kośa* or *Koṣa* are the words used for lexicons in the Sanskrit literature.

3.1 The Lexicon

Lexicon is a vocabulary of a language, including its words and expressions. Lexeme is the fundamental unit of the lexicon of a language. Lexeme is a word or stem that is a meaningful unit in a language and coincides with the abstract unit underlying a given set of inflected forms. It is an abstract unit

[1]समाम्नायः समाम्नातः तम् इमं समाम्नायं निघण्टवः इति आचक्षते। (निरुक्तम् १.१)

[2]आद्यं नैघण्टुकं काण्डं द्वितीयं नैगमं तथा, अस्यार्थः ''एकार्थवाचिनां पर्य्यायशब्दानां सङ्घो यत्र प्रायेणोपदिश्यते तत्र निघण्टुशब्दः प्रसिद्धः।'' तादृशेष्वमरसिंहवैजयन्तीहलायुधादिषु दशनिघण्टव इति व्यवहारात् एवमत्रापि पर्य्यायशब्दसङ्घोपदेशादाद्यकाण्डस्य नैघण्टुकत्वम् तस्मिन् काण्डे त्रयोऽध्यायाः तेषु प्रथमे पृथिव्यादिलोकदिक्कालादिद्रव्यविषयाणि नामानि, द्वितीये मनुष्यतदवयवादिद्रव्यविषयाणि, तृतीये तदुभयद्रव्यगततनुबहुत्वह्रस्वत्वादिधर्मविषयाणि (□□□□□ □□ □□□□□□□□□□ □□□□□ □□□□□□□□□□, □□□□, □□□.□, □.□□□□)

of morphological analysis in linguistics. A lexical database is an organized description of the lexemes of a language.

Lexicon is "the collection of words". Dictionary, Thesaurus and Encyclopedia are different types of lexicons.

- Dictionary - collection of words and its meanings, some times examples, which are arranged in alphabetical order.
- Thesaurus - collection of words and its synonyms, which are arranged following some structure, such as ontological classification.
- Encyclopedia - collection of words which are arranged in alphabetical order. Each entry in an encyclopedia consists of an essay describing various aspects of the entry.

Kośa literature in Indian tradition is very rich and at the same time it has lot of variety also. Kośas are typically organised following an ontological structure. Since the kośas were memorised orally, in order to facilitate the memorisation with ease, most of these follow metrical compositions.

3.2 Sanskrit Lexicons (Kośas)

In the book "Indian Lexicography", Claus Vogel explains the characteristics of Indian lexica as - "Indian dictionaries may be synonymic or homonymic. The synonymic dictionaries are systematic catalogues of words with one and the same meaning (*ekārtha, samānārtha*); A neat and proper discrimination of both categories is not always practicable since many synonymic lexica include a homonymic section or chapter as well."[3]

Some of the synonymous kośas are *Nāmamālā, Śabdaratnākara, Śabdacandrikā* etc.. Homonymous are *Anekārthasamuccayaḥ, Anekārthadvanimañcarī, Viśvaprakāśa* etc.. *Dhanvantarinighaṇṭu, Sabdacandrikā, Rājanighaṇṭu* come from the domain of medicine. *Pārasīprakāśa* of *Vedāṅgarāya* covers the domain of Indian astronomy and astrology. The *Rājavyavahārakośa* of *Raghunātha* presents technical

[3] A History of Indian Literature; Vol. 5, Claus Vogel, P.305

terms used in administration.

Lexicons which have combination of both synonymous and polysemous words are *Amarakośa, Vaijayantīkośa, Abhidānacintāmaṇī* etc.. Some focus on etymology or some on grammar while some are arranged on the basis of syllables, and so on.

3.3 Modern Sanskrit Lexicons

The method of representing the lexical units in metrical style gradually faded in the modern times, because without the help of any commentaries to get the proper meaning of the word became very difficult. This changed the content of the dictionaries and also its organisation. The new representation style brought in clarity.

H. H. Wilson's A Sanskrit-English Dictionary, Sanskrit-English Dictionary by Theodore Goldstucker, A Sanskrit-Latin Dictionary by Bopp, Dictionary Classique Sanscrit-Francais of Emile Burnouf etc. are the oldest bilingual dictionaries.

Vācaspatyam compiled by *Taranatha Tarkavacaspati*, *Śabdakalpadruma* by *Raja Radhakanta Deva* etc. are some monolingual Sanskrit dictionaries.

Monier Monier-Williams' Sanskrit-English dictionary and English-Sanskrit dictionary, The Practical Sanskrit-English Dictionary compiled first by V.S Apte etc. are the famous modern Sanskrit bilingual dictionaries.

3.4 Electronic Lexicons

The aim of an electronic lexicon is different from that of printed dictionaries. The entries of an electronic lexicon, should contain all orthographical or inflectional variations. Since programming languages handle simple one or two dimensional data structures more easily, embedded entries as in printed dictionaries should be avoided for an electronic lexicon. Information for generating all the derivative forms is necessary, whereas gloss or definition

may not necessarily be a top priority.

WordNets are the most popular electronic lexicons. WordNets are available for many languages like English, Italian, German, Spanish, Portuguese, Hebrew, Romanian, Latin etc. Indian languages like Hindi, Sanskrit, Marathi, Telugu, Tamil, Malayalam, Konkani etc..

VerbNet, ConceptNet, PropNet, FrameNet etc. are the other famous electronic lexical databases.

3.4.1 WordNet

WordNet is an electronic lexical database. It is a large lexical database of English language. This work was inspired by the psycholinguistic theory of human lexical memory. Nouns, verbs, adjectives and adverbs are organised in sets of synonyms, each of which represents a lexical concept. These sets of synonyms are interconnected by a certain number of relations and organised into taxonomies. WordNet distinguishes two types of relations: lexical relations, such as synonymy, antonymy, polysemy etc., and semantic relations, such as hypernymy, hyponymy, holonymy, meronymy etc..

WordNet was developed at Princeton University's Cognitive Science Laboratory. Over the years many linguists, lexicographers, students, and software engineers have contributed to the project. These group started to develop this lexical database in 1985.

Word forms in WordNet are represented in their familiar orthography; word meanings are represented by synonym sets (synsets) - lists of synonymous word forms that are interchangeable in some context. Synset is the basic unit of WordNet. It groups English words into sets of synonyms called synsets, and provides short, general definitions, with some examples.

E.g. Synset :: {example, illustration, instance, representative}
Definition :: an item of information that is typical of a class or group;
Examples :: "this patient provides a typical example of the syndrome"; "there is an example on page 10".

Minimality, coverage and replaceability are the three principles that determine a synset:

1. Minimality: Only the minimal set that uniquely identifies the concept is used to create the synset,

   - E.g., {ghar, kamaraa} (room)

   ghar –which is ambiguous– is not by itself sufficient to denote the concept of a room. The addition of kamaraa to the synset brings out this unique sense.

2. Coverage: The synset should contain all the words denoting a concept. The words are listed in order of (decreasing) frequency of their occurrence in the corpus.

   - {ghar, kamaraa, kaksh} (room)

3. Replaceability: The words forming the synset should be mutually replaceable in a specific context. Two synonyms may mutually replace each other in a context C, if the substitution of the one for the other in C does not alter the meaning of the sentence. Consider,

   Synset : {svadesh, ghar} (motherland)– {apanaa desh} (the country where one is born)
   Example : amerikaa meN do saal bitaane ke baad shyaam svadesh/ghar lauTaa
   Gloss : America in two years stay after Shyam motherland returned.
   English Translation : 'Shyam returned to his motherland after spending two years in America'[4]

WordNet has information belonging to four Parts of Speech of English Language, viz nouns, verbs, adjectives and adverbs. The other Parts of Speeches viz prepositions, conjunctions, pronouns, etc. are not covered in WordNet.

[4]Kulkarni et.al, 2009,

Three types of words are there in WordNet. Polysemous, Homonymous and Monosemous. Polysemous words refers to a word with multiple related meanings with same spelling. Homonymous words have the same spelling and the same pronunciation but have different meanings. Words with single meaning are termed as monosemous.

WordNet records various relations between synonym sets or synsets. Two kinds of relations are recognized: lexical and semantic. Lexical relations hold between word forms, it is word - word relation; and semantic relations hold between word meanings or concepts, it is meaning - meaning relation. Semantic relations are the dominating relations in WordNet.

Semantic Relations

Semantic relation is a relation between meanings or concepts, that are represented by synsets.

Hypernymy and hyponymy, meronymy and holonymy, troponymy and entailment, attribute, similar-to, etc. are some semantic relations.

- Hypernymy and Hyponymy
  - If synset 'A', is a kind of synset 'B' then 'A' is the hyponym of 'B' and 'B' is the hypernym of 'A'.
    - E.g.:– *chloric acid* is hyponym of *acid* and *acid* is the hypernym of *chloric acid*
- Holonymy and Meronymy
  - Synset 'A' is a meronym of synset 'B', if 'A' is a part of 'B', conversely 'B' is a holonym of 'A', if 'B' has 'A' as a part. Holonyms and Meronyms can be as three pairs:-
    - *Member of* and *Has Member*

      E.g.:- Island is a *member of* archipelago, archipelago *has member* as an island.
    - *Substance of* and *Has substance*

      E.g.:- Paper *has substance* cellulose, cellulose is a *substance of* paper.

  * *Part of* and *Has part*

    E.g.:- Chapter is a *part of* text, text *has part* as chapter.

- Troponymy and Entailment
  - These are verb relations. Troponymy is a particular kind of entailment. Activities which are temporally co-extensive are related as Troponymy.
    * E.g.:- *limp* and *walk* (limping is the temporally co-extensive work of walking. So it became the troponym of walking)
    * *lisp* and *talk*
  - Activities which are having, proper temporal inclusion, are related as Entailment.
    * E.g.:- *snore* and *sleep* (the sense *snore* have proper temporal inclusion in the sense *sleep*. So snoring is the entailment of sleeping)
    * *buy* and *pay*

- Attribute
  - It links together synset 'A' with an attribute synset 'B', when 'B' is a value of 'A'
    * E.g.:- measure - is the attribute of standard and nonstandard. (standard and non standard are "values" of measure)

- Similar-to
  - It links two adjective synsets.
    * E.g. (1):- Synset1 is {last}, and meaning is *'Immediately Past'* and
      Synset2 is {Past}, and meaning is *'Earlier than the present time'*.
    * E.g. (2):- Synset1 is {last}, and meaning is *'occurring at the time of death'*.
      and
      Synset2 is {dying}, and meaning is *'in or associated with the process of passing from life or ceasing to be'*

Lexical Relations

Lexical relations are the relations between word or words in a synset. Antonymy relation is a lexical relation, which relates between two words from two different synsets. Rest of the words from the synset will not have any effect of the lexical relations.

Antonymy is the famous lexical relation in WordNet. Pertainym of, etc. are the other lexical relations.

- Antonymy
  - It links together two words that are opposites of each other.
    * E.g.:- *beauty* and *ugliness*
    * E.g.:- *come* and *go*
- Pertainym of
  - It is an adjective relation. An adjective 'A' is related to another adjective or to a noun 'B' if 'A' pertains to 'B'.
    * E.g.(1):- *bicentennial*(adj) pertains to *centennial*(adj) pertains to *century*(n)
    * E.g.(2):- *animatedly*(adv) pertains to *animated*(adj)

3.4.2 IndoWordNet

Indian language WordNets are collectively called as IndoWordNet. It is also a multilingual lexical database. 16 out of 22 official languages of India, have started making their WordNets under the leadership of IIT Bombay. These languages are: Hindi, Marathi, Konkani, Sanskrit, Nepali, Kashimiri, Assamese, Tamil, Malyalam, Telugu, Kannada, Manipuri Bodo, Bangla, Punjabi and Gujarati. These languages cover the length and breadth of India.

3.4.3 Euro-WordNet

EuroWordNet is a multilingual lexical database for several Europian languages. This is the first multilingual electronic lexicon. The aim of the EuroWordNet-project is the development of a database with WordNets for

English, Spanish, Dutch and Italian, similar to the Princeton WordNet1.5, which contains basic semantic relations between words in English. The Dutch, Italian and Spanish WordNets will be linked to the WordNet1.5 using equivalence relations. The resulting multilingual database can directly be used in (multi-lingual) information retrieval.

3.4.4 MultiWordNet

MultiWordNet is a multilingual lexical database including information about English and Italian words. It is an extension of WordNet 1.6, a lexical database for English developed at the Princeton University. The Italian synsets are created in correspondence with the Princeton WordNet synsets, whenever possible, and semantic relations are imported from the corresponding English synsets; i.e., we assume that if there are two synsets in Princeton WordNet and a relation holding between them, the same relation holds between the corresponding synsets in Italian. The Spanish, Portuguese, Hebrew, Romanian and Latin WordNets are the member languages of the MultiWordNet model.

3.4.5 VerbNet

VerbNet is the largest on-line verb lexicon currently available for English. It is first released in 2005. It is a hierarchical domain-independent, broad-coverage verb lexicon with mappings to other lexical resources such as WordNet, FrameNet etc.. VerbNet is organized into verb classes extending Levin (1993)[5] classes through refinement and addition of subclasses to achieve syntactic and semantic coherence among members of a class. Each verb class in VerbNet is completely described by thematic roles, selectional restrictions on the arguments, and frames consisting of a syntactic description and semantic predicates with a temporal function.

3.4.6 ConceptNet

ConceptNet[6] is a commonsense knowledge base and natural language processing tool-kit which supports many practical textual-reasoning tasks

[5] Verb index from "English Verb Classes And Alternations: A Preliminary Investigation", by Beth Levin, published by The University of Chicago Press, 1993.

[6] http://web.media.mit.edu/~hugo/conceptnet/

over real-world documents including topic-gisting, analogy-making, and other context oriented inferences. The knowledge base is a semantic network presently consisting of over 1.6 million assertions of commonsense knowledge encompassing the spatial, physical, social, temporal, and psychological aspects of everyday life. ConceptNet is generated automatically from the 700,000 sentences of the Open Mind Common Sense Project - a World Wide Web based collaboration with over 14,000 authors. Fig.3.1 shows the ConceptNet representation of - "An excerpt from ConceptNet's semantic network of commonsense knowledge. Compound (as opposed to simple) concepts are represented in semi-structured English by composing a verb (e.g. 'drink') with a noun phrase ('coffee') or a prepositional phrase ('in morning')"[7].

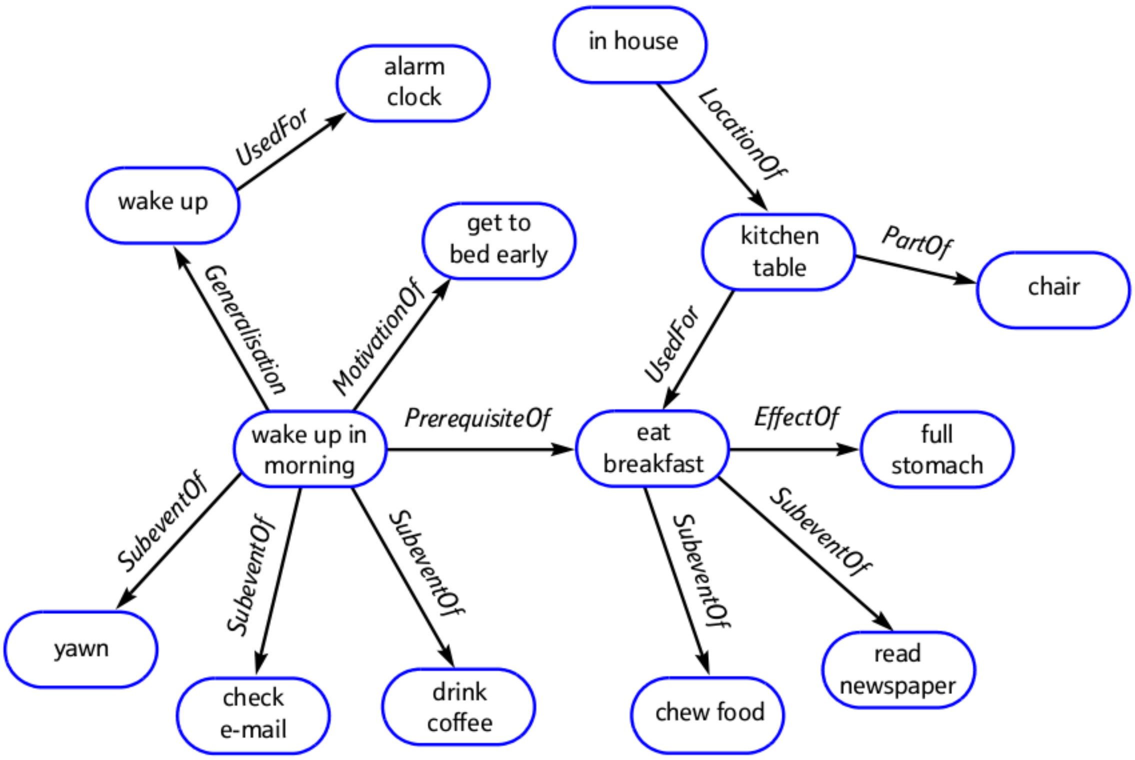


Figure 3.1: Knowledge representation in ConceptNet

[7]Liu,H, 2004

Chapter 4

Gender Information in Amarakośa

Amarakośa is primarily named as *Nāmaliṅgānuśāsana*. The meaning of the name is "a work that deals with instructions related to the gender of nouns". This book in agreeing with the true meaning of the name, *Nāmaliṅgānuśāsana*, gives the gender instruction of nouns. In the introduction part of the book, *Amarasiṁha* gives the general guidelines. Through these verses, the normal rules for deciding the gender of a noun is explained. Through out *Amarakośa* some gender indications are given wherever the explanations are needed. These verses and the gender indicating words within *Amarakośa* from a meta-language. In what follows we describe this meta-language.

4.1 Liṅganirdhāraṇa in Amarakośa

Amarasiṁha lists nominative singular (*pradhamaikavacana*) words through the verses of *Amarakośa* . For some exceptional cases like भार्या जायाथ पुंभूम्नि दाराः (2.6.6 a.k.) he uses the special form like *dārāḥ* and indicates it's specialty like *puṃbhūmni* also, because the stem *dārā* will always use in masculine-plural. For illustrating the gender, *Amarasiṁha* uses specific words such as *puṃ, strī, astrī, napuṃ,* etc. which fit extremely well in the verse. He describes the rules as :-

प्रायशोरूपभेदेन साहचर्याच्च कुत्रचित्।

स्त्रीपुंनपुंसकं ज्ञेयम् तद्विशेषविधेः क्वचित्।। (1.1.3 a.k.)
भेदाख्यानाय न द्वन्द्वो नैकशेषो न सङ्करः।
कृतोऽत्र भिन्नलिङ्गानामनुक्तानां क्रमादृते।। (1.1.4 a.k.)
त्रिलिङ्ग्यां त्रिष्विति पदम् मिथुने तु द्वयोरिति।
निषिद्धलिङ्गं शेषार्थम् त्वन्ताथादि न पूर्वभाक्।। (1.1.5 a.k.)

In these ślokas he describes various techniques he employed to code the gender information like *rūpabedhaḥ, sāhacaryam, viśeṣavidhiḥ* etc. We discuss each of these with examples.

4.1.1 Rūpabedhena

From the word form

कौमोदकी गदा खड्गो नन्दकः। (1.1.28 a.k.)

Here *kaumodakī* and *gadā* are in feminine gender and *khaḍgaḥ* and *nandakaḥ* are in masculine gender. He didn't mention any information about the gender of these words, but it should be inferred using our world knowledge.

Qualifier-Qualificand relation

तत्परो हनुः। (2.6.90 a.k.)

It is very difficult to decide the gender of the word *hanuḥ*. Because words ending in 'n' have the same form in masculine and feminine gender in nominative singular case. Here the adjective *tatparaḥ* qualifies *hanuḥ* which is in masculine gender. There is a rule that qualifier and qualificand should be in same case, number and gender.

विशेष्यस्यैव यल्लिङ्गं विभक्ति वचने च या।
तानि सर्वाणि योज्यानि विशेषणपदेष्वपि।।[1]

From this rule we can conclude that the word *hanuḥ* is in masculine gender.

[1] Cited by Tārānātha Tarka Vācaspati, Vol.6, p.4913

Pronoun

कुतूः कृत्तेः स्नेहपात्रं सैवाल्पा कुतुपः पुमान्। (2.9.33 a.k.)

The words *pumān* and *kutupaḥ* are masculine. So one may get confused with the gender of the words *kutūḥ* and *kṛtteḥ*. But the pronoun *sā* clarifies it and removes the confusion and the gender of these two words is fixed as feminine.

4.1.2 Sāhacaryāt

In case of भानुः करः (1.3.33 a.k.), *bhānuḥ* can be both masculine as well as feminine. The proximity of *karaḥ* indicates the gender of *bhānuḥ* should be masculine.

4.1.3 Viśeṣavidhiḥ

Sometimes *Amarasiṁha* himself uses some special words to indicate the gender wherever it is not clear from any of the above means. This is the "*viśeṣavidhiḥ*" in *Amarakośa* . E.g. भेरी स्त्री दुन्दुभिः पुमान् (1.7.6 a.k.) etc. Here the word *bherī* is feminine and *dundubhiḥ* is masculine.

4.1.4 Bhedākhyānāya na dvandvo

Amarasiṁha frequently uses coordinative compounds in his ślokas. But while making compounds he follows some rules. *Pāṇini* allows in his grammar that different gendered words can be a part of coordinative *(dvandva)* compound. But in *Amarakośa* the words which have gender number combinations (feminine plural, feminine dual etc.), or more than one gendered words are not included in coordinative compound. For example :-

विद्याधरो अप्सरोयक्षरक्षोगन्धर्वकिन्नराः। (1.1.11 a.k.)

Here *apsaras* have a special gender viz. feminine plural, than other words in this coordinative compound. Considering only this line it is difficult to decide the gender of the word *apsaras*. Here he treated अप्सरोयक्षरक्षोगन्धर्वकिन्नराः as a co-coordinative compound, but in the following line it is mentioned that the gender of the word *apsaras* is feminine plural.

स्त्रियां बहुष्वप्सरसः स्वर्वेश्या उर्वशीमुखाः (1.1.52 a.k.)

Here the confusion for desiding gender is solved, using *viśeṣavidhiḥ*.

4.1.5 Ekaśeṣaḥ na

In case of the words which are in different gender he avoids *ekaśeṣaḥ*. E.g.

नभः खं श्रावणो नभाः। (3.3.232 a.k.)

Here, the first *nabhaḥ* is the synonym of sky and it is in neuter gender. The second *nabhāḥ* is the synonym of *śrāvaṇa* and it is in masculine gender. The verse could be composed as खश्रावणौ तु नभसी. Then the paraphrase would be नभः च नभः च नभसी and the gender will be neuter only as per the Pāṇinian rule परवल्लिङ्गं द्वन्द्वतत्पुरुषयोः[2]. If he uses *ekaśeṣaḥ* principle, the information may be lost. To get *nabhaḥ* in both masculine and neuter *Amarasiṁha* does not use *ekaśeṣaḥ*.

4.1.6 Saṃkaraḥ na

If synonyms are in different genders *Amarasiṁha* arranges words in a specific order. For example :-

स्तवः स्तोत्रं स्तुतिः नुतिः। (1.6.11 a.k.)

In this verse *stavaḥ* is in masculine gender, *stotraṃ* is in neuter gender, and *stutiḥ* and *nutiḥ* are in feminine gender. Had he composed as स्तुतिः स्तोत्रं स्तवो नुतिः then it will become very much confusing as regards gender identification. *Amarasiṁha* didn't follow any rule that a particular gender word should occur first. E.g. :- consider

जनुर्जननजन्मानि जनिरुत्पत्तिरुद्भवः। 1.4.30 a.k.

Here *janurjananajanmāni* is in neuter gender, *janirutpattiḥ* is in feminine gender *udbhavaḥ* is in masculine gender.

If a word has three genders the word *triṣu* is used. E.g. :-

तटं त्रिषु। (1.10.7 a.k.)

[2]अष्टाध्यायी 2/4/26

taṭaḥ is in masculine, *taṭī* is in feminine, *taṭaṃ* is in neuter genders. The word *dvayoḥ* indicates the word has masculine and feminine genders. E.g. :-

अश्विनिद्वयोः। (1.1.47 a.k.)

It means the word *aśviniḥ* is in both masculine and feminine genders. If the indicator word has negation then it indicates the other two genders. E.g. :-

उटजोऽस्त्रियाम्। (2.2.6 a.k.)

the word *uḍaja* is *astriyām* i.e masculine as well as neuter, and not feminine

4.1.7 Gender Indicators in Amarakośa

strī and ***strīyāṃ*** for feminine gender
pum and ***puṃsi*** for masculine gender
napuṃ and ***klībam*** for neuter gender
astrī, na strī and ***punnapuṃ*** for both masculine and neuter genders
strīnapuṃ for both feminine and neuter genders
strīpuṃ, dvayoḥ, dve and ***dvau*** for both feminine and masculine genders
triṣu for all the three genders
and ***avyaya*** for indeclinable
nā is also used by *Amarasiṁha* to indicate masculine gender E.g. :- निधिर्ना शेवधिः 1.1.71 a.k.
bhūmni and ***bahuṣu*** are used for indicating *bahuvacana.* E.g. :-

भार्या जायाथ पुंभूम्नि दाराः स्यात्तु कुटुम्बिनी। (2.6.6 a.k.)

and

स्त्रियां बहुष्वप्सरसः स्वर्वेश्या उर्वशीमुखाः। (1.1.52 a.k.)

These are the gender indicators used by *Amarasiṁha.*

4.1.8 Tu anta, atha ādi

In ślokas the words *tu* and *atha* are to be connected with the consecutive word for getting the meaning. *"tu anta"* indicates the token will take place after *tu*, and the preceding word will be the meaning of the token, like :-

nagarītvamarāvatī. Here *Amarāvatī* is the token and *nagarī* is the meaning. In the case of *atha ādi*, before *atha* the token will take place and the succeeding word will be the meaning of the token. E.g. *javo'tha śīghram.* Here *java* is the token and *śīghram* is the meaning.

The *anvaya* or relations between *tu* or *atha* and other words are of four types depending on the category of the other word – 1) noun 2) gender 3) pronoun 4) indeclinable.

Noun word

शचीन्द्राणी नगरीत्वमरावती। (1.1.45 a.k.)

The word *tu* which is connects with the word *amarāvatī* here and not with the word *nagarī.*

जवोऽथ शीघ्रं त्वरितम्। (2.8.73 a.k.)

Here the word *atha* connects with the word *tvaritam* and not with the word *śīghraṃ.*

Gender word

पुंसित्वन्तर्धिः (1.3.12 a.k.)

Here *tvanta puṃsi* (*puṃsi* the word that ends with *tu*) connects with *antardhiḥ.*

शस्तं चाथ त्रिषु द्रव्ये। (1.4.26 a.k.)

Here *athādi triṣu* (the word *triṣu* which starts with *atha*) connects with *dravye. Puṃsi* and *triṣu* these two gender informations will go to the words *antardhiḥ* and *dravye.*

Pronoun word

तस्य तु प्रिया। (1.1.44 a.k.)

Here *tasya* the pronoun will connect with the word *priyā.*

Indeclinable word

वा तु पुंसि।

Here *vā* the indeclinable will connect with the gender informating word *puṃsi.*

The *atha* indicates *atho* which is the synonym of *atha* also. E.g. :-

पोताधानमथो झषः। (1.10.19 a.k.)

4.2 Liṅgādisaṅgrahavarga

The last chapter of *Amarakośa* named as *liṅgādisaṅgrahavarga. Amarasiṁha* again explains the rules regarding gender in detail. These rules may be divided into eight parts. Those are *strīliṅgaprakaraṇam* (rules for feminine gendered words), *pulliṅgaprakaraṇam* (rules for masculine gendered words), *napuṃsakaliṅgaprakaraṇam* (rules for neuter gendered words), *puṃnapuṃsakaliṅgaprakaraṇam* (rules for masculine-neuter gendered words), *strīpulliṅgaprakaraṇam* (rules for feminine-masculine gendered words), *strīnapuṃsakaliṅgaprakaraṇam* (rules for feminine-neuter gendered words), *triliṅgaprakaraṇam* (rules for feminine-masculine-neuter gendered words), and *paravalliṅgaprakaraṇam* (rules for the gender of the compound-ending-words). Some suffixes indicate only a particular gender, so he lists those suffixes as well. Sometimes he lists the words themselves particularly when these words can not be captured under any generalities. Sometimes he declares that synonyms of the words are also in the same gender only. E.g. :-

"नाम विद्युन्निशावल्ली वीणादिग्भूनदीह्रियाम्।
अदन्तैर्द्विगुरेकार्थो न स पात्रयुगादिभिः॥" (3.5.3 a.k.)

The words *vidyut, niśā, vallī, vīṇā, dik, bhūmi, nadī, hrī* and their synonyms are in feminine gender. *adantaikārthadvigu* are feminine E.g. *pañcamūlī, pañcākṣarī* etc. But not in the case of *pātra, yuga* etc. E.g. *pañcapātram, cauryugam, tribhuvanam,* etc.

So we can cross check the gender information of the words which was listed by *Amarasiṁha* , using *liṅgādisaṅgrahavarga.*

Commentaries of *Amarakośa* are very much useful to decide the perfect gender when there is a confusion. *Vyākhyāsudhā* or *Rāmāśramī* were given first preference in case of conflict. The Malayalam Commentaries based on Sudha named as *pārameśvarī* and *triveṇī* were also useful. The other Commentaries like *Ṭīkāsarvasvam, Amarakośodghāṭanam* and *Maheśvaraṭīkā* also referred to when in doubt. After doing the gender marking according to the rules given by *Amarasiṁha*, we did a cross check with Devadatta Tivari's "*Devakośa arthāt Amarakośa*" and Colebrooke's commentary on *Amarakośa* .

4.3 Comparison with Monier Williams Dictionary

We did a comparison of the gender of words in *Amarakośa* with the gender of those words as mentioned in Monier Williams Sanskrit-English Dictionary. The comparison was done automatically by through some simple "perl" scripts.

4.3.1 Monier Williams Sanskrit - English Dictionary

It is a Sanskrit – English Dictionary developed by Sir Monier Monier Williams (MW), first published by Oxford University Press in 1899. He was the second occupant of the Boden Chair of Sanskrit at Oxford University. It is an autentative modern Sanskrit dictionary. It's another advantage is, it is available in electronic form.

We did a comparison between the gender information given by *Amarasiṁha* with MW's gender information. The purpose of this exercise was to see how much deviation is there as regards the gender, over a period of centuries.

4.3.2 The Result of The Comparison

Total tokens in *Amarakośa* are 11,580 and among these 5886 words had the same gender in MW. The other words, where there was a deviation fall into three categories - partial match, extra gender or total mismatch.

Partial Match

These are the cases where each *Amarakośa* as well as *MW* report more than one genders for a word, but the genders in both the lexicon do not match totally. They match only partially. E.g. :- the *Prātipadika "garta"* has masculine and feminine gender in *Amarakośa* and masculine and neuter gender in MW. So here masculine is a common gender and in *Amarakośa* feminine is an extra gender, not found in MW and in MW neuter gender is an extra gender not found in *Amarakośa*. Figure 4.1 shows the Venn diagram of the partial match of the gender in *Amarakośa* and MW.

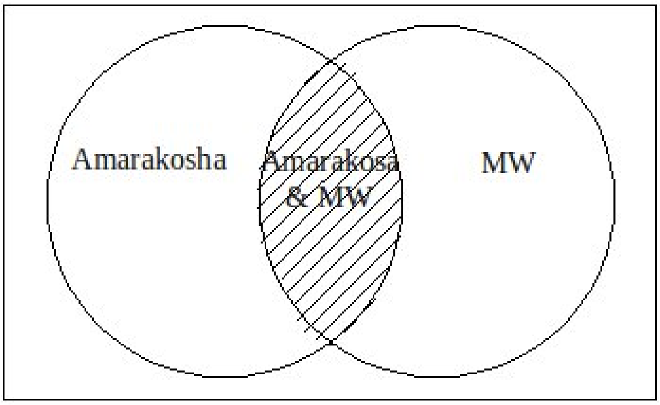


Figure 4.1: Partial match of Amarakośa and MW

Only three such words were found. For all these words *Amarasiṁha* clearly mentions the gender and hence there is even no doubt about the interpretation of their gender.

1. The *prātipadika "kroḍa"* is in feminine and neuter in *Amarakośa* according to the verse -

   स्यान्न ना क्रोडं भुजान्तरम्। (2.6.77 a.k.)

   But it is in masculine and neuter gender in MW[3]. In *Amarakośa* the word *nā* is used to denote masculine gender. Here *Amarasiṁha* negates

[3]MW. p.323

the masculine gender by *na nā*. Negation indicates the other two genders, so the word is in feminine and neuter genders.

2. The *prātipadika "viśva"* is in feminine and neuter genders in *Amarakośa* according to the verse -

   स्त्रीनपुंसकयोर्विश्वम् (2.9.38 a.k.)

   But in MW it is in masculine and feminine gender[4].

3. The *prātipadika "garta"* is in masculine and feminine genders according to the *Sudhāvyākhyā* of *Amarakośa*. *Sudhākāra* quotes *Rabhasa* and *Haima*, the Sanskrit lexicographers[5]. But in MW it is marked as masculine and neuter genders[6].

Extra Gender in Amarakośa or in MW

In some cases either *Amarakośa* or MW has an extra gender over and above what the other lexicon includes. Like these more than 5000 words are there in *Amarakośa*. Figure 4.2 and figure 4.3 represents Venn diagrams of the inclusion.

This clearly indicates the diachronic change in the value of the gender.

Mismatches of Word Genders in Amarakośa and in MW

Mismatches of the genders between *Amarakośa* and MW are more important than inclusion or intersection of genders. In the Sanskrit word's gender informations, there can be variations according to lexicons or *liṅgānuśāsanasūtram* or modern type dictionaries. Lexicons or *liṅgānuśāsanasūtram* are representing the gender which was used in ancient times. There can be changes in gender according to their different type usages in modern times, because usages will change according to time. So it is very much important to watch how it is differed.

In some cases, the verses of *Amarakośa* itself provides gender information using some abbreviations, but in these types of case also MW is not matching

[4] MW. p.992

[5] *Vyākhyāsudhā* p.87.

[6] MW. p.349

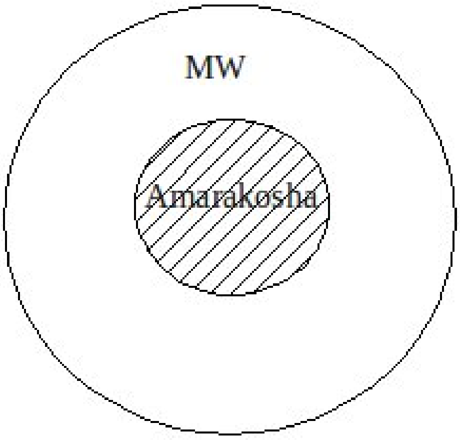


Figure 4.2: Amarakośa gender included in to MW

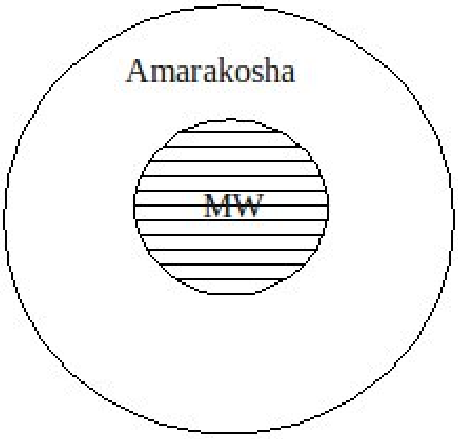


Figure 4.3: MW gender included in to Amarakośa

with this some times. So according to *Amarasiṁha* those are correct. These types of cases are five in total *Amarakośa* . List is given in Appendix-B.

E.g.:- The *prātipadika "sārasana"* is in feminine gender according to the verse -

क्लीबे सारसनम् च। (2.6.109 a.k.)

Here *Amarasiṁha* indicating it as neuter using the word *klībe*. But in MW it is marked as masculine gender[7].

Liṅgānuśāsanasūtra's are also helping to decide gender when it has confusing gender. *Sudhā* itself describes about this sūtras when it is needed. So from this also we can decide gender.

E.g.:-The *prātipadika "chadis"* is in feminine gender according to the *Liṅgānuśāsanasūtra* "छदिः स्त्रियामेव"[8] and *Amarakośa* Commentaries are also marking it as feminine only. But in MW it's gender is recorded as neuter[9].

Some times the gender of the word can be decided from verses through it's word endings. But, some of these type of cases are also not matching with MW. These types of cases from *Amarakośa* are given in Appendix-B.

E.g.:- *ajagava* is the *prātipadika* in the meaning of the 'bow of god Śiva'. *Amarakośa* marks it as neuter gender through the verse -

पिनाकोऽजगवं धनुः। (1.1.35 a.k.)

But in MW it is marked as masculine gender[10].

For some cases we can decide the word gender from the compound ending. Because there is a rule in Pāṇini's vyākaraṇa that "परवल्लिङ्गं द्वन्द्वतत्पुरुषयोः[11]" It tells that the compounds in *dvandva* and in *tatpuruṣa* will take the gender of the last word. So we can decide the last word's gender in the *dvandva* and *tatpuruṣa* compound. Some of these type of cases are also not matching with MW. These types of cases are five in *Amarakośa* .

1. The *prātipadika "dhaivata"* is masculine gender marked as *Amarakośa* .

निषादर्षभगान्धारषट्जमध्यममधैवताः (1.1.7 a.k.)

[7]M.W p.1209

[8]नपुंसकलिङ्गाधिकारः - 21

[9]MW. p.404

[10]MW. p.9

[11]अष्टाध्यायी 2/4/26

The *dvandva* compound ending is in masculine gender here, and the ending word is *dhaivata*. So we can decide that the *prātipadika "dhaivata"* is in masculine gender. But in this case MW marked it as neuter gender[12].

2. The *prātipadika "tejana"* is in masculine gender in *Amarakośa* according to the verse -

   वेणुमस्करतेजनाः (2.4.161 a.k.)

   Here this is a *dvandva* compound ending in masculine gender, and the ending word is *tejana* also. According to *Pāṇini* the gender of *tejana* will be masculine. But in MW it is marked as neuter gender[13].

3. The *prātipadika "saṃyuga"* is in masculine gender in *Amarakośa* according to the verse -

   संप्रहाराभिसम्पातकलिसंस्फोटसंयुगाः (2.8.105 a.k.)

   Here this is a *dvandva* compound ending in masculine gender, and the ending word is *saṃyuga* also. According to *Pāṇini* the gender of *saṃyuga* will be masculine. But in MW it is marked as neuter gender[14].

4. The *prātipadika "rauhiṣa"* is in neuter gender in *Amarakośa* according to the verse -

   पौरसौगन्धिकध्यामदेवजग्धकरौहिषम् (2.4.166 a.k.)

   Here this is a *dvandva* compound ending in neuter gender, and the ending word is *rauhiṣa* also. According to *Pāṇini* the gender of *rauhiṣa* will be neuter. But in MW it is marked as masculine gender[15].

[12]MW. p.520
[13]MW. p.454
[14]MW. p.1112
[15]MW. p.891

5. The *prātipadika "bhūstṛṇa"* is in neuter gender in *Amarakośa* according to the verse -

   मालातृणकभूस्तृणे (2.4.167 a.k.)

   Here this is a *dvandva* compound ending in neuter gender, and the ending word is *bhūstṛṇa* also. According to *Pāṇini* the gender of *bhūstṛṇa* will be neuter. But in MW it is marked as masculine gender[16].

In some cases it is very difficult to decide the gender of compound words in *Amarakośa*. E.g. :-

स्वर्गनाकस्त्रिदिवस्त्रिदशालयाः (1.1.6 a.k.)

Deciding the gender of the word *tridiva* from this compound is very much difficult. The word is in the middle of the coordinative compound. In these types of cases we are following the information from the commentaries. For the word *tridiva*, commentaries are marking it as in masculine gender. But MW is marking as neuter and feminine gender[17]. These types of cases are listed in Appendix-B.

4.4 Polysemy Distribution in Amarakośa

Amarakośa has 4,053 synsets. Some of the words fall under more than one synsets, and thus are ambiguous. Most of these polysemous words belong to the *nānārthavargaḥ* of the third *kāṇḍa* which lists the polysemous words alphabetically according to their endings like *kānta, khānta, gānta* etc. *nānārthavargaḥ* has 814 polysemous words. In *Amarakośa*, 21% (2545) words have more than one meaning. The polysemy distribution in the *Amarakośa* is summarized in Table 4.1. There is only one word *hari* in *Amarakośa* which has as many as 14 senses, the word *antarā* belongs to 13 synsets, and the word *go* has 12 synsets. We note that almost 65% words (7459 words) belong to a single synset and thus are not ambiguous.

16 MW. p.761
17 MW. p.458

No. of meanings	No. of words	Words
14	1	*hari*
13	1	*antarā*
12	1	*go*
10	2	*kriā, kūṭa*
9	2	*rasa, vṛṣa*
8	8	*dhātu, dharma, vasu, ariṣṭa...*
7	9	
6	18	
5	49	
4	136	
3	330	
2	1015	
1	7459	

Table 4.1: Polysemy Distribution

Chapter 5

Knowledge Structure in Amarakośa

The Indian tradition of transmitting knowledge orally is on the verge of vanishing. As the oral transmission demands, Indian traditional educational culture was organised to be *formal and intensive* as opposed to the modern culture which is more *informal and extensive* (Wood, 1985). In traditional circumstances, a child would receive his education largely by oral transmission, mainly through rote-learning. The method employed was through recitation and remembering. A child is taught the alphabet (varṇamālā), he would memorise a few verses, subhāṣitas, and then start reciting a dictionary of synonymous words -- the Amarakośa -- till it is memorised. It typically would take anywhere between 6 months to a year to memorise a list of approximately 10,000 Sanskrit words arranged as a list of synonyms. The close inspection of the structure of the Amarakośa gives much more insight into the way the words are organised. When a student memorises it, though in the beginning it appears as a linear list of words, as he starts understanding the meaning of the words, reads the commentaries on this text and starts using these words, the linear structure unfolds into a knowledge web with various links.

The Amarakośa printed in the form of a book just shows the linear order, and the index at the end of the book point to various words for easy references. But there is much more to it than just a linear order. The knowledge a student acquires through various commentaries and also its practical use in his own field of expertise -- be it *āyurveda, vyākaraṇa* or *sāhitya*, is

in the form of various links. With the modern education culture that is dominated by the use of computers as a tool, which relies more on the secondary memories such as books, computers, and the World Wide Web, than the human memory, it is necessary to make the *implicit* knowledge in Amarakośa *explicit*. The computers have an advantage over the printed books. Computers can represent multi-dimensional objects, and thus one can navigate through the whole structure and at the same time with the powerful search facilities can search complex queries. Here in this chapter we present a computational model that, can 'visualise' various kinds of links in Amarakośa, and provide a database model to store these links in order to facilitate automatic extraction of these links as an answer to a search query.

5.1 Amarakośa

As explained in the first chapter *Amarakośa* consists of 1068 ślokas. These are divided into three kāṇḍas and each kāṇḍa is divided in to vargas. There are 25 vargas in total. Amarakośa contains 11,580 content words (tokens). Some of the tokens are repeated either within a kāṇḍa or across the kāṇḍas leading to only 9,031 types.

Amarakośa as is well known consists of *paryāyapada*'s (synonymous words). A set of synonymous words is termed as a synset. Each synonym may span over one or more verses. The following verse, e.g., provides a synonym for the word *jambuka*.

> स्त्रियां शिवा भूरिमायगोमायुमृगधूर्तकः।
> शृगालवञ्चकक्रोष्टुफेरुफेरवजम्बुकः॥ (2.5.5 a.k.)

5.2 Organisation of synsets within a varga

Except the polysemous words (*nānārthavargaḥ*), all other synsets in a varga show some semantic relation to the varga it belongs to and sometimes even to the preceding or following synsets. These semantic relations indicate various kinds of relations. They may be classified as hierarchical or associative. The hypernym indicating a more general term or the hyponym showing a more specific term are the examples of hierarchical relation. Similarly the holonym-meronym relation marking the whole-part relation is also a

hierarchical relation. In addition various other relations are indicated by the adjacency of the synsets. These may be termed as associative relations, which indicate some kind of association of one synset with the other. This association may be the association among human beings, or the association of certain objects with certain other objects. We illustrate below some such relations with examples.

5.2.1 Example 1: Viṣṇuh

The verses from 1.1.18 to 1.1.29 describe various synsets representing *viṣṇu*, and objects related to/associated with *viṣṇu*. The relations, as is evident from the following description, are kinship relations such as father, brother, son, grandson, wife, and also associated objects such as conch, discus, sword, vehicle, etc. (See Figure 5.1).

viṣṇu (1.1.18 - 1.1.22)[1]
- *kṛṣṇa*'s father (1.1.22)
- *kṛṣṇa*'s elder brother (1.1.23 - 1.1.24)
- *kāmadeva* (1.1.25 - 1.1.26)
  - floral arrows of *kāmadeva* (1.1.26)
  - physical arrows of *kāmadeva* (1.1.26)
  - son of *kāmadeva* - *aniruddha* (1.1.27)
- wife of *viṣṇu* - *lakṣmī* (1.1.27)
- Special devices/equipments of *viṣṇu* (1.1.28)
  (conch, discus, sword, jewel, bow, horse, mark,etc.)
- *kṛṣṇa*'s charioteer, minister (1.1.28)
- *kṛṣṇa*'s younger brother (1.1.28)
- *viṣṇu*'s vehicle - *garuḍa* (1.1.29)

5.2.2 Example 2: Samayaḥ

The verses from 1.4.1 to 1.4.9 deal with words related to time, units of measurement, special names of special days, etc.

[1] The English translations of the subheadings, which are given here and in the following examples, describing the ślokas are taken from Colebrooke's commentary on *Amarakośa* (Colebrooke, 1808).

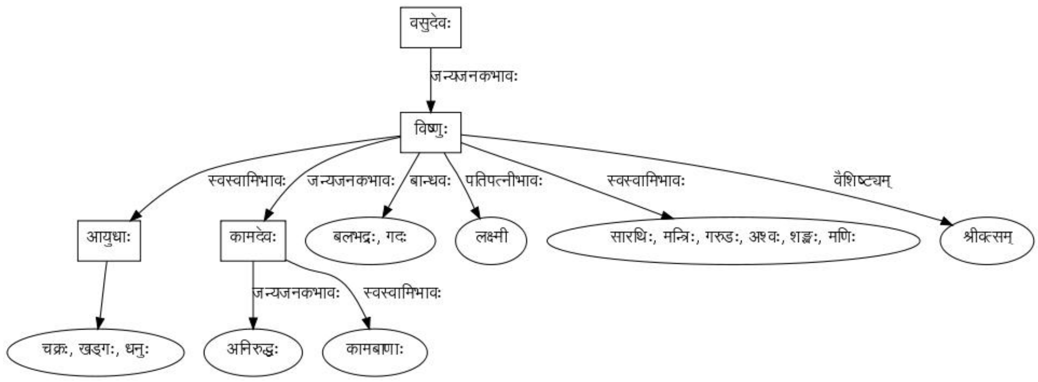


Figure 5.1: Relations of *viṣṇu*

- Time (1.4.1)
    - Lunar day (1.4.1)
        - First lunar day (1.4.1)
    - {Day (1.4.2)
        - Morning (1.4.2 - 1.4.3)
        - Twilight (1.4.3)
        - Evening (1.4.3)
        - First four hours of a day (1.4.3)
        - Second four hours of a day (1.4.3)
        - Third four hours of a day (1.4.3)
        - Period of the day (1.4.3)
        - Night (1.4.3 - 1.4.4)
            - A dark night (1.4.5)
            - A moonlit night (1.4.5)
            - A night and two days (1.4.5)
            - First part of night (1.4.6)
            - Midnight (1.4.6)
            - Sequence of nights (1.4.6)
    - Space of three hours (1.4.6) }
        - Last day of the half month (1.4.7)
            - Precise moment of the full or the new moon (1.4.7)
        - Full moon day (1.4.7)
            - Full moon whole day(1.4.8)
            - Full Moon with a little gibbous on part of a day (1.4.8)

        - No moon day (1.4.8)
            - waning crescent (1.4.9)
            - No moon whole day (1.4.9)

In this example we also see violation of nesting. In between the synsets related to *lunar day* and *last day of the month*, the synsets related to *day* (which refers to the apparent solar motion) are intervened.

5.2.3 Example 3: Kṣatriyaḥ

Here is a group of verses from 2.8.1 to 2.8.10 belonging to the *Kṣatriyavargaḥ*. The words here refer to the king, military, sministers, various category of people engaged in the services of kings, etc.

- Man of the military tribe (2.8.1)
    - King (2.8.1)
        - An emperor (2.8.2)
        - Universal monarch (2.8.2)
        - King over a country (2.8.2)
        - Paramount sovereign (2.8.3)
    - Multitude of kings (2.8.3)
    - Multitude of military tribe (2.8.4)
        - Minister (2.8.4)
            - Deputy minister (2.8.4)
        - Priest (2.8.5)
        - Judge (2.8.5)
        - King's companions (2.8.5)
        - Body guards of a king (2.8.6)
        - Warder (2.8.6)
        - Superintendent (2.8.6)
            - Village Superintendent (2.8.7)
            - Superintendent of many villages (2.8.7)
            - Superintendent of Gold (2.8.7)
            - Superintendent of Silver (2.8.7)
            - Superintendent of the womens' apartments (2.8.8)
                - Outside guard of the womens' apartment (2.8.8)
            - attendant of a king (2.8.9)
                - eunuch (2.8.9)

Prince whose territories lie on the frontiers of those of the enemy (2.8.9)
Neighboring prince (2.8.9)
Prince whose territories lie beyond those of the friend (2.8.10)
Enemy in the rear (2.8.10)

5.3 Implicit relations

These were three samples from three distinct topics involving totally different kind of relations. All these relations are semantic in nature. A more detailed study of such examples showed that following relations occur more frequently.

- *avayavāvayavī* (part-whole relation)
- *parāparājāti* (is a kind of relation)
- *janyajanaka* (child-parent relation)
- *patipatnī* (husband-wife relation)
- *svasvāmi* (master-possession relation)
- *ājīvikā* (livelihood)

5.3.1 Is a part of (*avayavāvayavī*)

Syn(रात्रिः)[2] = शर्वरी, क्षणदा, क्षपा, निशा, निशीथिनी, रजनी, रात्रि, विभावरी, तमस्विनी, तमी, त्रियामा, यामिनी, नक्तम्, दोषा, वसति, श्यामा.
and
Syn(रात्रिमध्यः) = अर्धरात्र, निशीथ.

अर्धरात्र, निशीथ are part of निशा, रजनी, रात्रि, etc.. Hence रात्रिमध्यः is marked to be is_a_part_of (अवयव of) रात्रिः

Similarly प्रदोष, रजनीमुख (Syn (रात्रिप्रारम्भः)) are also part of निशा, रजनी, रात्रि, etc.. Hence रात्रिप्रारम्भः, where Syn (रात्रिप्रारम्भः)= प्रदोष, रजनीमुख

[2]synset of रात्रिः

also bears a part_of relation with रात्रिः. See the Figure 5.2.

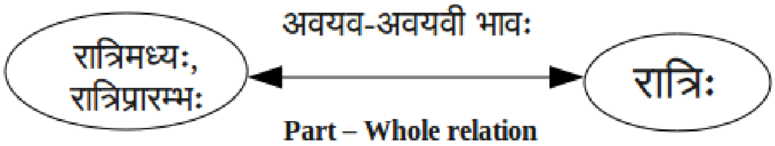


Figure 5.2: Part-Whole Relation

5.3.2 Is a kind of (*parāparājāti*)

Syn(नदी) = नदी, सरित्, आपगा, ह्लादिनी, निम्नगा, शैवलिनी, स्रवन्ती, स्रोतस्विनी, तरङ्गिणी, तटिनी, धुनी, द्वीपवती, कूलङ्कषा, निर्झरिणी, रोधोवक्रा, सरस्वती, भोगवती, सिन्धु, वाहिनी.
and
Syn(गङ्गा) = सुरनिम्नगा, गङ्गा, जह्नुतनया, विष्णुपदी, भागीरथी, भीष्मसू, त्रिपथगा, त्रिस्रोतस्.

सुरनिम्नगा, गङ्गा, जह्नुतनया,....... are a kind of नदी, सरित्, आपगा, ..., etc.. Hence गङ्गा is marked to be is_a_kind_of नदी. See the Figure 5.3.

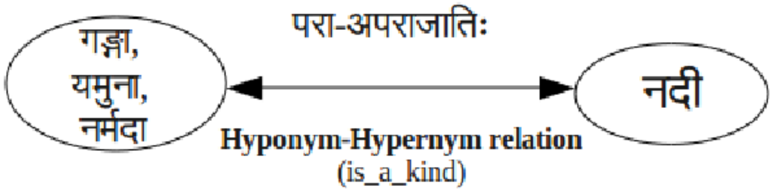


Figure 5.3: Is-a-kind-of Relation

5.3.3 Child-parent relation (*janyajanakabhāva*)

Syn (जयन्तः) = पाकशासनी, जयन्त.
and
Syn (इन्द्रः) = इन्द्र, बिडौजस्, मघवन्, मरुत्वत्, पाकशासन, सुनासीर, वृद्धश्रवस्, पुरन्दर, पुरुहूत, जिष्णु, लेखर्षभ, शक्र, शतमन्यु, दिवस्पति, वृषन्, वृत्रहन्, गोत्रभिद्, सुत्रामन्, वासव,

वज्रिन्, बलाराति, शचीपति, सुरपति, वास्तोष्पति, हरिहय, जम्भभेदिन्, नमुचिसूदन, स्वाराज्, मेघवाहन, सङ्क्रन्दन, तुराषा, दुश्च्यवन, आखण्डल, ऋभुक्षिन्, सहस्राक्ष, कौशिक, घनाघन, पर्जन्य, हरि.

The head-words जयन्तः and इन्द्रः shares the *janyajanakabhāva* (parent-child relation). See the Figure 5.4.

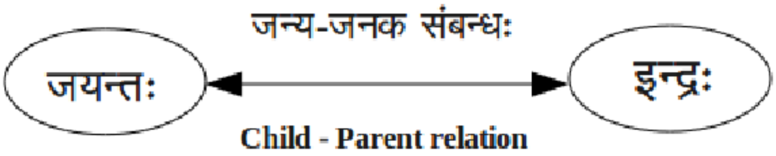


Figure 5.4: Parent-child Relation

5.3.4 Husband-wife relation (*patipatnībhāva*)

Syn(लक्ष्मी) = भार्गवी, हरिप्रिया, इन्दिरा, कमला, क्षीरसागरकन्यका, क्षीरोदतनया, लक्ष्मी, लोकजननी, लोकमातृ, मा, पद्मा, पद्मालया, रमा, श्री, वृषाकपायी.
and
Syn(विष्णुः) = हृषीकेश, केशव, कृष्ण, माधव, नारायण, स्वभू, वैकुण्ठ, विष्णु, विष्टरश्रवस्, दामोदर, अच्युत, गरुडध्वज, गोविन्द, जनार्दन, पीताम्बर, पुण्डरीकाक्ष, शार्ङ्गिन्, विष्वक्सेन, दैत्यारि, चक्रपाणि, चतुर्भुज, इन्द्रावरज, मधुरिपु, पद्मनाभ, उपेन्द्र, वासुदेव, त्रिविक्रम, अधोक्षज, बलिध्वंसिन्, कंसाराति, पुरुषोत्तम, शौरि, श्रीपति, वनमालिन्, देवकीनन्दन, जलशायिन्, कैटभजित्, मुकुन्द, मुरमर्दन, नरकान्तक, पुराणपुरुष, श्रीवत्सलाञ्छन, विश्वम्भर, विश्वरूप, विधु, यज्ञपुरुष, लक्ष्मीपति, मुरारि, अज, अजित, अव्यक्त, वृषाकपि, बभ्रु, हरि, वेधस्.

Here the head-word *lakṣmī* has the husband relation with the head-word *viṣṇuh* and *viṣṇuh* has the wife relation with *lakṣmī*. See the Figure 5.5.

5.3.5 Master-possession relation (*svasvāmibhāva*)

Syn(विष्णोः मन्त्रिः) = उद्धव

,

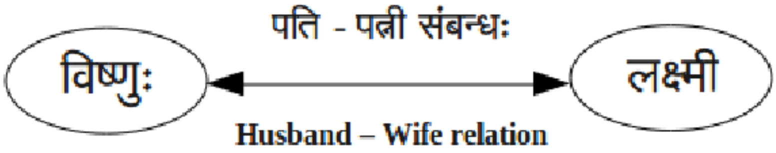


Figure 5.5: Husband-Wife Relation

Syn(विष्णोः सारथिः) = दारुक

,

Syn(गरुडः) = गरुड, गरुत्मत्, खगेश्वर, नागान्तक, पन्नगाशन, सुपर्ण, वैनतेय, विष्णुरथ, तार्क्ष्य, अहिभुज

and

Syn(विष्णुः) = हृषीकेश, केशव, कृष्ण, माधव, नारायण, स्वभू, वैकुण्ठ, विष्णु, विष्टरश्रवस्, दामोदर, अच्युत, गरुडध्वज, गोविन्द, जनार्दन, पीताम्बर, पुण्डरीकाक्ष, शार्ङ्गिन्, विष्वक्सेन, दैत्यारि, चक्रपाणि, चतुर्भुज, इन्द्रावरज, मधुरिपु, पद्मनाभ, उपेन्द्र, वासुदेव, त्रिविक्रम, अधोक्षज, बलिध्वंसिन्, कंसाराति, पुरुषोत्तम, शौरि, श्रीपति, वनमालिन्, देवकीनन्दन, जलशायिन्, कैटभजित्, मुकुन्द, मुरमर्दन, नरकान्तक, पुराणपुरुष, श्रीवत्सलाञ्छन, विश्वम्भर, विश्वरूप, विधु, यज्ञपुरुष, लक्ष्मीपति, मुरारि, अज, अजित, अव्यक्त, वृषाकपि, बभ्रु, हरि, वेधस्.

Here the head-word *viṣṇuh* has the master relation with the head-words विष्णोः मन्त्रिः, विष्णोः सारथिः and गरुडः, and vise versa these three have the possession relation with the head-word *viṣṇuh*. See the Figure 5.6

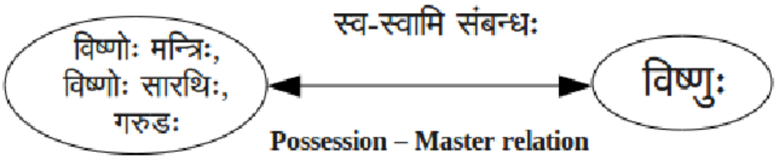


Figure 5.6: Master-possession Relation

5.3.6 Livelihood (*ājīvikā*)

The synset with head-word *matsya* is (अण्डज, झष, मत्स्य, मीन, पृथुरोमन्, शकुली, वैसारिण, विसार, अनिमिष) which denotes objects which act as a livelihood for the objects expressed through the concept of *dhīvara*, and hence the livelihood for the objects belonging to the synset *dhīvara* is marked as a *matsya*. (see Figure 5.7).

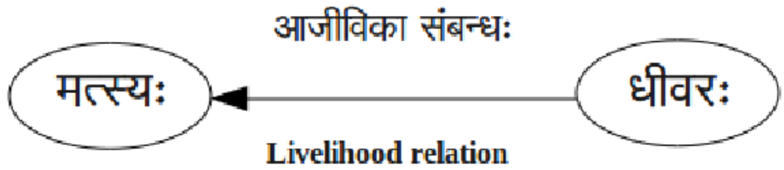


Figure 5.7: Livelihood Relation

For more examples, see the Appendix B.

There are a few other relations such as kinship relations, *ādhārādheya*, *vaṃśavaṃśīya* etc. But the instances of such relations were found to be rare.

Chapter 6

Ontological Representation scheme for Amarakośa

'Ontology' the word with Greek origin means "study of being or existence or reality". The study of existence of entities, their classification based on similarities or differences, the hierarchy involved in it come more close to the philosophical studies. Ontology also plays an important role in Knowledge Representation.

Knowledge Representation is a way of specification or representation of a concept. According to J. F. Sowa, it is a multidisciplinary subject that applies theories and techniques from three other fields: Logic, Computation, and Ontology.

Logic provides the formal structure and rules of inference.

Computation supports the applications that distinguish knowledge representation from pure philosophy.

Ontology defines the kind of things that exist in the application domain[1].

We can illustrate knowledge representation like this :- if we consider knowledge representation as a house construction, then the sketch of the house is provided by logic, construction works are undertaken by

[1] J.F Sowa,2000 Preface,XI,XII.

computation, and the materials for the house are supplied by ontology. Without the materials, using only sketch and construction works, we cannot create a house. Like that without the knowledge of existence, the logic and the computation cannot fulfill the knowledge representation of a concept.

6.1 Ontology

Ontology constitutes the major branch of philosophy viz. Metaphysics[2]. J.F Sowa explains metaphysics like this:- "The two sources of ontological categories are observation and reasoning. Observation provides knowledge of the physical world, and reasoning makes sense of observation by generating a framework of abstractions called *metaphysics*[3]." Later the term 'ontology' has been adopted by the Artificial Intelligence research into knowledge representation. The AI school deals with the organisation of knowledge about the universe. In order to provide a suitable structure to the knowledge, AI researchers need an ontology for the domain taken for application.

"The subject of ontology is the study of the categories of things that exist or may exist in some domain"[4].

"A choice of ontological categories is the first step in designing a database, a knowledge base, or an object-oriented system. In database theory the categories are usually called domains, in AI".

6.1.1 Definition of Ontology

WordNet lists two senses for the term "ontology". The first is given according to the computer science point of view and the second is according to the philosophy point of view.

1. "a rigorous and exhaustive organization of some knowledge domain that is usually hierarchical and contains all the relevant entities and

[2]Metaphysics is a branch of philosophy concerned with explaining the fundamental nature of being and the world.
[3]J.F Sowa,2000 Pg.No.51
[4]J.F.Sowa,2000 Pg.No.492

their relations", and the hypernymy relation shows like this[5] :-

```
=> arrangement, organization, organisation, system
    => structure
        => cognition, knowledge, noesis
            => psychological feature
                => abstraction, abstract entity
                    => entity
```

2. "the metaphysical study of the nature of being and existence", and the hypernymy relation shows like this :-

```
=> metaphysics
    => philosophy
        => humanistic discipline, humanities, liberal arts, arts
            => discipline, subject, subject area, etc.
                => knowledge domain, knowledge base, etc.
                    => content, cognitive content, etc.
                        => cognition, knowledge, noesis
                            => psychological feature
                                => abstraction, abstract entity
                                    => entity
```

The term ontology is defined in various ways by different branches of knowledge systems reflecting their own perception and usage. Here is a sample of definitions picked up from the wiktionary.

Definition by Wiktionary[6] :

- (uncountable, philosophy) The branch of metaphysics that addresses the nature or essential characteristics of being and of things that exist; the study of being qua being.
- (countable, philosophy) The theory of a particular philosopher or school of thought concerning the fundamental types of entity in the universe.

[5] http://wordnetweb.princeton.edu/perl/webwn

[6] http://en.wiktionary.org/wiki/ontology :: Date 13th January

- (logic) A logical system involving theory of classes, developed by Stanislaw Lesniewski (1886-1939).
- (computer science, information science) A structure of concepts or entities within a domain, organized by relationships; a system model.

6.2 History of Ontology

Historically, ontologies arise out of the branch of philosophy known as metaphysics, which deals with the nature of reality – of what exists. The traditional goal of ontological inquiry in particular is to divide the world "at its joints", to discover those fundamental categories, or kinds, into which the world's objects naturally fall.

The origin of Indian ontology can be traced back to the Indian philosophy viz. the *Vaiśeṣika* school which deals with the classification of *padārtha*s. Parallely the study of ontology in western knowledge systems can be traced back to Plato and Aristotle.

During the second half of the 20th century, philosophers extensively debated the possible methods or approaches to building ontologies, without actually building any very elaborate ontologies themselves. By contrast, computer scientists were building some large and robust ontologies (such as WordNet, Cyc and SUMO) with comparatively little debate over how they were built.

If we look at the history, we see three different school viz. Western ontology, Indian ontology and Upper level ontologies. Western and Indian ontological schools both were flourished simultaneously, and the upper level ontologies are nourished from the essence of both these schools.

6.2.1 Western Ontology

The concept of ontology was originated in western countries in early Greece with Plato and Aristotle, being the most prominent ontologists.

Plato

Plato was a disciple of the great ancient Greek philosopher Socrates. According to Plato reality is eternal, immutable, and consists of Forms. Form is completely separated from matter or material existents. He believed in the existence and reality of universals.

Aristotle

Aristotle described ontology as "the science of being qua being". The word 'qua' means 'in the capacity of'. According to this theory, ontology is the science of being in as much as it is being, or the study of beings in so far as they exist. He presented ten basic categories viz. substance, quality, quantity, relation, activity, passivity, having, situatedness, spatiality and temporality. In 1862 Franz Brentano organized all ten categories as the leaves of a single tree whose branches are labeled with other terms taken from Aristotle's works. Those are :- being, accident, property, inherence, directedness, containment, movement and intermediacy. Brentano's tree of Aristotle's categories is given in Figure 6.1[7]

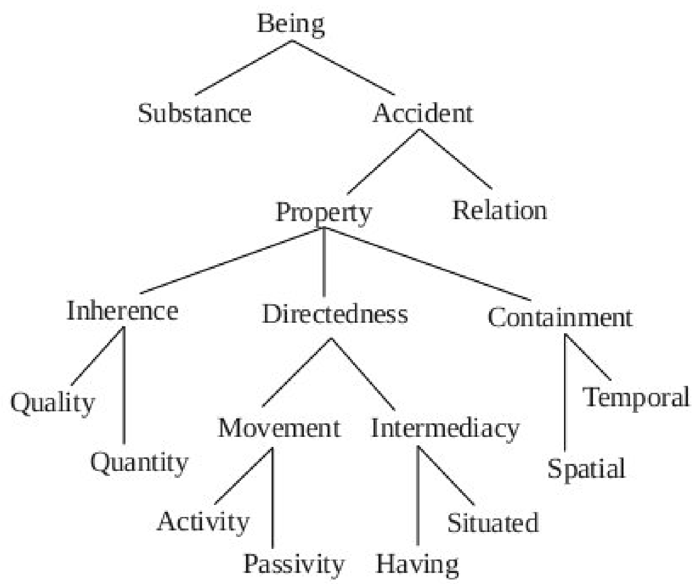


Figure 6.1: Brentano's tree of Aristotle's categories

[7]Knowledge Representation Pg.No. 56-57.

Thomas Aquinas

Thomas Aquinas incorporated Aristotelian ontology into Christian ideas and developed Christian philosophy and theology; issues of ontology became the subject matters of Scholasticiasm in the Middle Ages.

Martin Heidegger, Heraclitus, Edmund Husserl, Roman Ingarden, Immanuel Kant, Gottfried Leibniz, Parmenides, Charles Taylor, W. V. Quine, Gilbert Ryle, Jean-Paul Sartre, Hakim Bey, Spinoza, Ludwig Wittgenstein, Michael Dillon etc. are the other western ontologists.

6.2.2 Indian Ontology

Nyāya-Vaiśeṣika and *Sāṅkhya* are the major Indian philosophical schools that deal with ontology as the core of their subject. Among these *Nyāya-Vaiśeṣika* and *Sāṅkhya* are the realistic schools. *Gautama, Kaṇāda* and *Kapila* were the most prominent Indian ontologists. The other Indian schools of thoughts like *Yoga, Vedānta, Buddha, Jaina* etc. though they propose different theories about ontology, focus on subjects other than the ontology. Therefore only the ontological theories proposed by *Nyāya-Vaiśeṣika* and *Sāṅkhya* schools are taken for discussion here.

Sāṅkhya school

Kapila's school is the oldest school of Indian philosophy, which is named as *Sāṅkhya* school[8]. According to *Sāṅkhyakārikā* of *Īśvarakṛṣṇa* the ultimate goal of the *Sāṅkhya* school is salvation (*mokṣa*) form this universe which is filled with three types of sorrows known as *ādhyātmika*, *ādidaivika* and *ādibauddhika*. *Sāṅkhya* is a strongly dualistic philosophy that postulates everything in reality stems from *puruṣa* (self, *ātmā* or soul) and *prakṛti* (matter, creative agency or energy). There are many living souls (*Jīvātmā*) and they possess consciousness. *Prakṛti* consists of three dispositions known as qualities (*guṇa*s): *rajas*, *tamas* and *sattva*. The equilibrium of these three *guṇas* or qualities is known as *Prakṛti*. At first, the three were in equilibrium, but that equilibrium was disturbed by the arrival of *puruṣa*, and the world as we know it began to evolve from *Prakṛti*. *Sāṅkhya* denies the existence of God. Western dualism deals with the distinction between

[8]दर्शनशास्त्रस्येतिहासः Pg. no. 40

the mind and the body, whereas *Sāṅkhya* distinguishes between the soul and matter.

Sāṅkhya Categories

The twenty five categories of *Sāṅkhya* theory are explained by *Īśvarakṛṣṇa* in his *Sāṁkhyakārikā* like this :-

> प्रकृतेर्महांस्ततोऽहङ्कारस्तस्माद् गणश्च षोडशकः।
> तस्मादपि षोडशकात् पञ्चभ्यः पञ्चभूतानि॥ (सांख्यकारिका – २०)

According to *Sāṅkhya* school the whole universe is divided into two, *prakṛti* and *vikṛti* (*puruṣa*). The first part *prakṛti* is again divided into two as *vyakta* and *avyakta*. First perspective of *vyakta* is *mahattattva* and second perspective is *ahaṅkāra*. One part of the *ahaṅkāra* is filled with eleven organs and in the second part five objects (*pañca tanmātras*) are their. From each of these object (*tanmātra*) it generates related element. The detailed classification of *prakṛti* is given in Figure 6.2.

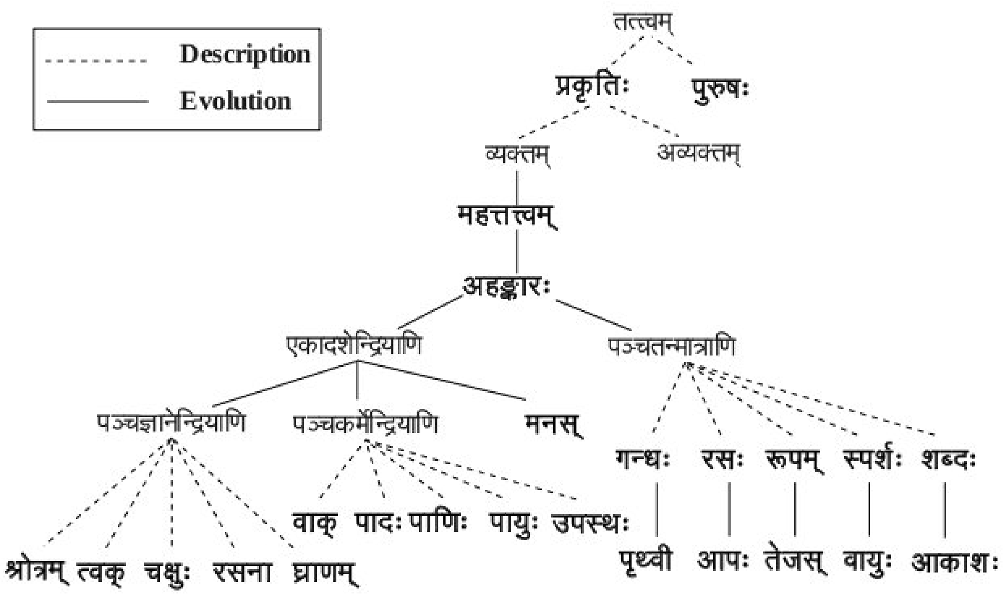


Figure 6.2: Sāṅkhya Classification of Universe

Nyāya School

Gautama is the celebrated founder of the Nyāya School or the logical school. He is also known as *Akṣapāda* or *Akṣacaraṇa* both meaning 'having eyes on his feet'[9]. He wrote *nyāyasūtra.* *Vātsyāyana* wrote the *bhāṣya* on *nyāyasūtra* for the better clarification. Again *Udyotakara* wrote *vārtika* on *Nyāyasūtrabhāṣya* for more clarifications. In 10th century A.D *Udayanācārya*, the founder of *Navya-nyāya* logic wrote *Nyāsūtrabhāṣyavārttikatātparyatīkā* on these three works.

Nyāya Categories

Sixteen categories are their in Nyāya school. Those are :- *pramāṇa* (the means of right knowledge), *prameya* (the object of right knowledge), *saṁśaya* (doubt), *prayojana* (purpose), *dṛṣtānta* (Example), *siddhānta*(Tenet), *avayava* (members of syllogism), *tarka* (confutation), *nirṇaya* (ascertainment), *vāda* (discussion), *jalpa* (wrangling), *vitaṇḍā* (cavil), *hetvābhāsa* (fallacy), *chala* (quibble), *jāti* (analogue), *nigrahasthāna* (a point of defeat).

Vaiśeṣika school

Kaṇāda has established the Vaiśeṣika school. It deals with the characteristics of entities. *Vaiśeṣika*, one among the six theistic schools of philosophy, is very scientific in presenting its concepts related to the matter or nature. Sage *Kaṇāda* has established the school of *Vaiśeṣika.* The term *'Vaiśeṣika'* is derived from the term *'viśeṣa'*, the fifth category listed by *Kaṇāda.* *Viśeṣa* is a kind of particularity. This being one among the theistic schools of Indian philosophy, has reduced the total cosmic entities into seven *padārthas* or the ontological categories.

Vaiśeṣika Categories

Seven fundamental 'titles' or 'categories' are accepted in Vaiśeṣikās, and then these are further subdivided. *Dravya* (Substance), *guṇa* (Quality), *karma* (Motion), *sāmānya* (Universals), *viśeṣa* (Particularity), *samavāya* (Co-Inherence) and *abhāva* (Negation). Here negation or non-beingness does

[9]Shastri Dharmendra Nath, 1976 Pg. 97.

not appear in *Praśastapada*'s[10] list.

There are nine classes of substances : *pṛthvī* (earth), *āpa* (water), *tejas* (fire), *vāyu* (air), *ākāśa* (ether), *kāla* (time), *dik* (direction), *ātman* (soul) and *manas* (mental organ).

There are twenty-four classes of qualities : *rūpa* (color), *rasa* (taste), *gandha* (smell), *sparśa* (touch), *saṁkhyā* (number), *parimāṇa* (dimension), *pṛthaktva* (separateness), *saṁyoga* (conjunction), *vibhāga* (disjunction), *paratva* (proximity), *aparatva* (prosteriority), *gurutva* (gravity), *dravatva* (liquidity), *sneha* (viscidity), *śabda* (sound), *buddhi* (intelligence), *sukha* (pleasure), *duḥkha* (pain), *iccā* (desire), *dveṣa* (aversion), *prayatna* (effort), *dharma* (merit), *adharma* (demerit) and *saṁskāra* (disposition)

Motion (*karman*) is divided into five : *utkṣepaṇa* (moving upward), *apakṣepaṇa* (moving downward), *ākuncana* (bending), *prasāraṇa* (stretching) and *ganama* (simple locomotion).

sāmānya (Universal) is a property which found common to various instances of an object, Eg. 'potness' (ghaṭatva) in common in all instances of ghaṭa, 'cowness' (gotva) in all instances of go etc.

The ultimate factors of individual identity are *viśeṣa*s (Particular). Wilhelm Halbfass explains about the residings of viśeṣa like this :- "They reside exclusively in the eternal, non-composite substances, that is in the individual atoms, souls, and mental organs, and in the unitary substances ether, space, and time. They account for the irreducible identity and distinctness of each of these entities."[11]

samavāya (Inherence) is the relation between cause and the effect or substances, which are inseparable (*ayutasiddha*s).

These are the main divisions of fundamental categories. The detailed classification is given in the Figure 6.4.

[10]The most important commentator of standard or old vaiśeṣika system of Kaṇāda and the author of *Padārthadharmasaṃgraha*.

[11]On Being and What There Is, Pg. 72.

6.2.3 Upper Level Ontologies

Upper-level ontologies capture mostly concepts that are basic for the human understanding of the world. They are "grounded" in the common sense that makes it difficult to formalize a strict definition for them. They represent prototypical knowledge using mainly taxonomic relations.

WordNet

WordNet qualifies as an upper ontology by including the most general concepts as well as more specialized concepts, related to each other not only by the subsumption relations, but by other semantic relations as well, such as part-of and cause. It has been widely used in Natural language processing research.

SUMO

The Suggested Upper Merged Ontology ("SUMO") is another comprehensive ontology project. It includes an upper ontology, created by the IEEE working group P1600.1 (predominantly by Adam Pease and Ian Niles). It is extended with many domain ontologies and a complete set of links to WordNet. It is freely available. The first four levels of SUMO ontological classification is given in the figure 6.3.

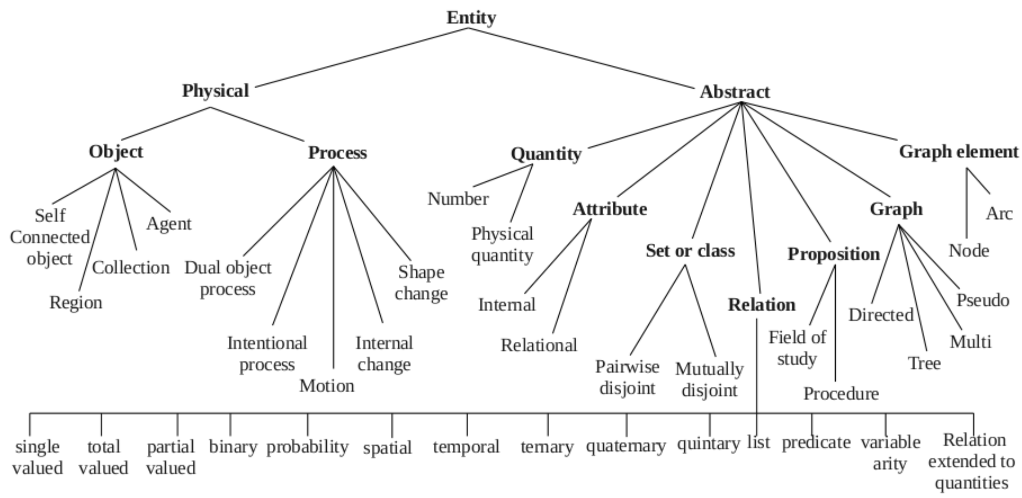


Figure 6.3: SUMO Ontology

Cyc

A well-known and quite comprehensive ontology available today is due to Cyc reference, a proprietary system under development since 1986, consisting of a foundation ontology and several domain-specific ontologies (called micro-theories). A subset of that ontology has been released for free under the name OpenCyc, and a more or less unabridged version is made available for non-commercial use under the name ResearchCyc.

6.3 Vaiśeṣika Ontology

Kaṇāda brings all objects of knowledge under seven categories. The first six are objects of the positive notion of being and the seventh one is the "absence" or negation. For example, substance is the substratum of quality and action. A book is a substance. Its color, extension, solidity, dimension etc. are its qualities. The motion is its action. These categories are used to understand/examine three classes of complex entities viz. real objects and events, structure of cognitive events and contents of communicative act. Kaṇāda's system is such that no two complex entities and events are ever identical, although the categories are invariant. The categories are six (seven) in number and they are - Substance (*dravya*), Quality (*guṇa*), Motion (*karma*), Universals (*sāmānya*), Particularity (*viśeṣa*), Co-Inherence (*samavāya*) (and Negation (*abhāva*)). Each *padārtha* has its particularity a distinct feature which is termed as its *viśeṣa*. Substance and quality are further sub-classified as Figure 6.4. This ontology is accepted by Naiyāyikas and further strengthened by Navya Naiyāyikas by proposing six constraints for a property to be a universal (*sāmānya or jāti*).

6.3.1 Jātibādhakās or impediments for deciding universals

The Nyaya-Vaisheshika theory of universal (*jāti*) does not recognize all general characteristics as universal. According to them the universal is a natural and eternal class-essence like *gotvam* (cowness), *ghaṭatvam* (potness) etc. which is permanent feature of a particular thing. Other general characteristics such as *unnatatvam* (tallness), *nīlavarṇatvam* (blueness) etc. which are adventitious features, are not universal (*jāti*) but are termed

as '*upādhis*'. This distinction is necessary to classify the *padārtha* with single inheritance. The logical basis for the distinction of *jāti* and *upādhi* is enumerated by *Udayana* as six 'impediments' called *jātibādhakāḥ*. Presence of anyone of these six is sufficient to disqualify a characteristic as an universal.

The six impediments are described in *Muktāvali* as -

> व्यक्तेरभेदतुल्यत्वं संकरोऽथानवस्थितिः।
> रूपहानिरसम्बन्धः जातिबाधकसंग्रहः।। (प्रत्यक्षखण्डः)[12]

Vyakteḥ abhedaḥ, tulyatvam, saṁkaraḥ, anavasthitiḥ, rūpahāniḥ and *asambandhaḥ* are the six impediments (*jātibādhakāḥ*).

Vyakteḥ abhedaḥ :: Any property belonging to a single thing is not an universal. E.g. *Ākāśa* being single, *Ākāśatva*, a property of being *Ākāśa* is not universal.

Tulyatvam :: Two general names which are the synonyms, and thus describe exactly same *padārtha* do not stand for different universals. E.g. *ghaṭatva* and *kalaśatva.* Here either *ghaṭatva* is a universal, or *kalaśatva* is a universal but not both, since both reside in the same set of individuals are indicating the same thing itself.

Saṁkara :: The cross-dividing properties which co-exist in some instances and also exclude one another in others are not to be recognized as universals.

Consider the five elements *pṛthvī* (earth), *jala* (water), *tejas* (fire) and *vāyu* (air) and *ākāśa.* *Bhūtatva* (being an element) is the universal property that exists in all these five elements. Of these the first four also have *mūrtatva* (mortality). Now the question is should *mūrtatva* be considered an universal ? We know that other than the first four elements, even the *manas* (mind) is also *mūrta* and hence has *mūrtatva.* So the first four elements have two universals in them and this leads to *saṁkara.*

As an another example, the animal kingdom may be classified as human beings and non-humans (animals), having *manuṣyatva* and

[12] Shastri Dharmendranath, Pg.No. 25

manuṣyetaraprāṇitva as two universals. Alternatively one may have *puruṣatva* and *strītva* as universals. But one can not have both pairs of universals simultaneously, since it leads to *saṁkara*.

Anavasthitiḥ :: The character recognition of which as a universal, leads to infinite regress, means universality (*jātitva*) is not to be considered as *jāti*, it can be *upādhi*. If universality was regarded as a universal then another universality will be required to synthesis the former with the latter and this process becomes infinite. Therefore the concept of universal is not to be regarded as corresponding to one more universal, namely, universality.

Rūpahāniḥ :: Ultimate difference cannot have any principle of unity, as it would contradict their essential nature (*viśeṣaṇāstu anantāḥ eva*). If *viśeṣatva* was regarded as an identity or universal, inhering in the *viśeṣā*s then mutual difference would be there. *viśeṣā*s being principles of ultimate differences, they cannot be differentiated from one another on the basis of any other characteristics. So *viśeṣatva* is also considering as *upādhi*.

Asambandhaḥ :: The universal by definition is, 'inherent' in its subject. This implies that the thing in which nothing can inhere cannot be the substrate of a universal. The categories of co-inherence (*samavāya*) and non-existence (*abhāva*) cannot have anything inhering in them. If *samavāyatva* is regarded as a universal, inhering in inherence (*samavāya*), then it would have to inhere in both its substrate and its relation with it, which is absurd. Such a position would also lead to infinite regress. Hence, nothing can be conceived as inhering in inherence. Similarly, no universal can be conceived to inhere in negation, because, it is not a positive entity. Therefore, *samavāyatva* and *abhāvatva* are not to be regarded as universals.

Thus these *jātibādhakas* impose constraints in the selection of *jātis*, and leads to multiple ways of classification. Choice of one way of classification forces other universal properties to be *upādhis*. This choice is typically guided by the application in hand. In what follows we build the *Nyāya-vaiśeṣika* ontology further and provide detailed classification so that we can classify the *padārthas* in *Amarakośa*. While selecting the properties on the one hand we had the concept of *yogyatā* in mind, that will help us in the process of *śābdabodha* and on the other hand we also were interested in understanding if

Amarasiṁha had any ontological classification in mind or not while compiling the words in the *kośa* form.

6.4 Ontological representation scheme for Amarakośa

Amarakośa is often compared to a thesaurus. From its classification into three *kāṇḍas* and each *kāṇḍa* into several *varga*s its structural organisation is quite clear. But in addition to this classification we observe further subclassification in each *varga*. In order to capture that ontology, just as a upper leavel ontology does, we classified each entry into a class, which helped us evolve the ontological classification. We followed both the top down as well bottom uo approach simultaneously in order to arrive at the ontological classification. For the top-down approach though our starting point was *Vaiśeṣika* ontology, we deviated from it a bit. Further we have also introduced *upādhi*s wherever we felt the need be. The detailed description of this scheme is given below. The graphical representation is also given in figure 6.4. *Jāti* classification is in the Figure 6.5, and *upādhi* classification is in Figure 6.6.

6.4.1 Jātiḥ and it's classification

While adopting *Vaiśeṣika* ontology to classify words in *Amarakośa* we noticed that we do not need some of the classes (since there are no instances of those in the *Amarakośa*) while we also required further sub-classification of some of them. The *Vaiśeṣika* ontological classification of *padārtha* is given in figure 6.4. The resulting classification of *padārtha*s in *Amarakośa* that emerged after the adoptation is shown in figure 6.5. In what follows we justify the additions or deletions of some of the nodes.

According to *Vaiśeṣika*, *padārtha* (reality) is the entity encompassing all things, viz. *dravya, guṇa, karma, sāmānya, viśeṣa, samavāya* and *abhāva* as classified in to seven. Out of these *Amarakośa* has instances only corresponding to *dravya, guṇa, karma, sāmānya* and *abhāva*. All those words which we could not classify are classified under *śeṣaḥ*.

Dravya Classification

Dravya is divided into nine according to *Vaiśeṣika*. These divisions are taken as it is in our scheme as well. Those are *pṛthvī, jala, teja, vāyu, ākāśa, kāla, dik* and *ātmā*. *Vaiśeṣika* ontology classifies first of them further into *nitya* and *anitya* and *ātmā* into *jīvātmā* and *paramātmā*. Since we are looking at *Amarakośa* from NLP point of view, this classification does not give us much mileage. Hence we deviated a bit from *Vaiśeṣika* ontology and further sub-classified three of them viz. *pṛthvī, tejas* and *ātmā* as per our needs, as described below.

1. The sub-classes of pṛthvī

There are different kinds of things which come under *Pṛthvī* in *Amarakośa*. All the elements under *Pṛthvī* are classified on the basis of two properties viz. *cala/acala* and *sajīva/nirjīva*. In addition for the celestial elements, we have created one more node viz. *alaukika* to account for celestial objects, we created the subnodes with *alaukika* only when there was an instance of the category with celestial object. We give below the classification describing each node with an example. The number of sub-nodes is shown in parenthesis against each node. A definition and example also given here.

- *pṛthvī* (5)
  - *calasajīvaḥ* (3)
    - * the thing which is alive and can move
      E.g. *manuṣyaḥ, jantuḥ* etc.
  - *calanirjīvaḥ* (0)
    - * the thing which is not alive but can move
      E.g. *rathaḥ, ḍolā, pālakī* etc.
  - *alaukikacalanirjīvaḥ* (0)
    - * the thing which is not alive, movable and celestial
      E.g. *puṣpakam*
  - *acalasajīvaḥ* (7)
    - * the thing which is alive and not movable
      E.g. *vṛkṣaḥ, bhrūṇam etc.*

  - *acalanirjīvaḥ* (4)
    * the thing which is not alive and not movable
      E.g. *chatram, mārgaḥ etc.*

1.1 The sub-classes of calasajīvaḥ

The category *calasajīvaḥ* is classified into three as *manuṣyaḥ, manuṣyetaraḥ* and *alaukikacetanaḥ*. All these nodes contain the body qualities, not the soul qualities[13]. The classification is given here.

- *alaukikacetanaḥ* (0)
  - All the celestial beings
    * E.g. *Śacī, Aruṇaḥ* etc.
- *manuṣyaḥ* (0)
  - human beings
    * E.g. *dhīvaraḥ, rājā* etc.
- *manuṣyetaraḥ* (2)
  - non-human beings
    * E.g. *siṃhaḥ, matsyaḥ* etc.

1.1.1 The sub-classes of manuṣyetaraḥ

Manuṣyetaraḥ node is classified as two viz. *jantuḥ* and *alaukikaprāṇī.* The second node represents the celestial non-human beings. The *jantuḥ* node represents all non-human beings. It is further divided in to six according to the modern scientific classification. The classification is given below.

- jantuḥ (6)
  - non-human living being
    * E.g. *sarpaḥ, kūrmaḥ* etc.
- *alaukikaprāṇī* (0)

[13]body comes under *pṛthvī* according to *Vaiśeṣika*

- non-human celestial being
  * E.g. *airāvatam, garuḍaḥ* etc.

1.1.1.1 The sub-classes of jantuḥ

- *jalīyaḥ* (0)
  - water body
    * E.g. *matsyaḥ, śaṅkhaḥ* etc.
- *ubhayacaraḥ* (0)
  - the animals which can live in both water and earth
    * E.g. *maṇḍūkaḥ, kūrmaḥ* etc.
- *sarīsṛpaḥ* (0)
  - reptiles
    * E.g. *sarpaḥ, saraṭaḥ* etc.
- *stanapāyī* (0)
  - mammals
    * E.g. *vānaraḥ, hiraṇaḥ* etc.
- *pakṣī* (0)
  - birds
    * E.g. *śukaḥ, kākaḥ* etc.
- *kīṭaḥ* (0)
  - insects
    * E.g. *jalaukaḥ, vṛścikaḥ* etc.

1.2 The sub-classes of acalasajīvaḥ

The node *acalasajīvaḥ* classifies the plant world and non-movable living things. It is divided into seven categories. The plant world is also classified according to the modern science only. In this there is a node named *alaukikasasyaḥ* which marks celestial plants. The classification is given below.

- *acalasajīvavastu* (0)
  - non-movable living things.
    * E.g. aṇḍam, bhrūṇam etc.
- *vṛkṣaḥ* (0)
  - trees
    * E.g. *āmraḥ, kharjuraḥ* etc.
- *latā* (0)
  - creepers
    * E.g. *mallikā, yūthikā* etc.
- *oṣadhiḥ* (0)
  - shrubs
    * E.g. *nīlī, bākucī* etc.
- *tṛṇam* (0)
  - grasses
    * E.g. *elā, jaṭāmāṁsī* etc.
- *jalīyasasyaḥ* (0)
  - water plants
    * E.g. *padmam, kumudam* etc.
- *alaukikasasyaḥ* (0)
  - celestial plants
    * E.g. *devavṛkṣaḥ*

1.3 The sub-classes of acalanirjīvaḥ

Acalanirjīvaḥ node is classified according to the necessities only. It is divided into four classes. The classification is given below.

- *alaukikācalanirjīvavastu* (0)
  - celestial non-movable, non-living things
    * E.g. *kāmabāṇaḥ, viṣṇoḥ maṇiḥ* etc.
- *sthānam* (3)
  - places
    * E.g. *mārgaḥ, nadī* etc.
- *mūlakam* (0)
  - minerals
    * E.g. *abhrakam, pāradaḥ* etc.
- *acalanirjīvavastu* (0)
  - non-movable, non-living thing
    * E.g. *chatram, cāmaram* etc.

1.3.1 The sub-classes of sthānam

- *alaukikasthānam* (0)
  - celestial places
    * E.g. *indravanam, kuberapurī* etc.
- *mānavanirmitiḥ* (0)
  - places or things which are created by men
    * E.g. *kūpaḥ, mārgaḥ* etc.
- *prākṛtikasthānam* (0)
  - natural places (not created by men)
    * E.g. *nadī, parvataḥ* etc.

2. The sub-classes of tejas

According to the *Vaiśeṣika* ontology *tejas* is divided into four viz. *bhauma, divya, udarya* and *ākaraja*, but in this scheme we did some modifications. *Bhauma tejas* will go under the node *tejas*. *Divya tejas* is divided into two according to our necessity as *nakṣatram* and *grahaḥ*. Examples of *udarya tejas* is not available in *Amarakośa* so this class is totally avoided. *Ākaraja tejas* is named as *dhātuḥ*. Like this *tejas* is classified as three in this scheme. The classification is given below.

- *tejas*
  - *nakṣatram* (0)
    * all kinds of stars

      E.g. *druvaḥ, kārtikā etc.*
  - *grahaḥ* (0)
    * all planets

      E.g. *sūryaḥ, candraḥ etc.*
  - *dhātuḥ* (0)
    * all kinds of metals

      E.g. *suvarṇam, rajatam etc.*

3. The sub-classes of ātmā

According to *Vaiśeṣika* ontology *ātmā* is divided into two as *jīvātmā* and *paramātmā*. But in this scheme it is divided as four viz. *īśvaraḥ, devatā, ṛṣiḥ* and *devayoniḥ*. According to Indian purāṇas *ātmā* can be classified as *siddhaḥ, sādhakaḥ* and *sāmānyaḥ*. Again *sāmānya* is classified into *devayoniḥ* and *manuṣyayoniḥ*. Here the category *siddhaḥ* is named as *devatā*, *sādhakaḥ* is named as *ṛṣiḥ*, *devayoniḥ* is taken as it is. In *Amarakośa* their is not a single entry which is related to *manuṣyayoni*. There are entries like *puruṣaḥ, strī* etc.. Those are considered under the category named *manuṣyaḥ*, which comes under *pṛthvī*, because these are the *śārīrika guṇa*s of *manuṣya*, not *ātmaguṇa*s. According to *purāṇa* the category named *īśvaraḥ* is created and it marks *trimūrtis* viz. *brahmā, viṣṇu* and *maheśvara*. The classification is given below.

- *ātmā*
  - *īśvaraḥ* (0)
    - *trimūrtis* viz. *brahmā, viṣṇu* and *maheśvara*
      E.g. *brahmā, viṣṇu, maheśvara*
  - *devatā* (0)
    - all deities
      E.g. *indraḥ, lakṣmī, yamaḥ* etc.
  - *ṛṣiḥ* (0)
    - sages
      E.g. *buddhaḥ, agastyaḥ* etc.
  - *devayoniḥ* (0)
    - demi-gods or demons
      E.g. *rākṣasaḥ, yakṣaḥ, kinnaraḥ* etc.

Guṇa Classification

In the *Vaiśeṣika* ontology *guṇa* is classified into twenty four sub-divisions. The *Amarakośa* classification need not have all these classes, so what ever classes are necessary to classify *Amarakośa* words, only those are adapted to this scheme, also some of the classes from *vaiśeṣika* ontology, are merged in to a single category. According to this scheme *guṇa* is classified into eight classes viz. *rūpam, rasaḥ, gandhaḥ, parimāṇaḥ, śabdaḥ, buddhiḥ, adṛṣṭam* and *mānasikabhāvaḥ*. *Adṛṣṭam* marks both *dharma* and *adharma*. This division is agreed by *Vaiśeṣika* ontology also. The last class in this classification named as *mānasikabhāvaḥ* contains all kinds of mental feelings like *sukham, duḥkham, dveṣa* etc. The classification is given here.

- *guṇaḥ* (7)
  - *rūpam* (0)
    - colour
      E.g. *śuklaḥ, nīlaḥ* etc.
  - *rasaḥ* (0)
    - taste

E.g. *madhutra, amla* etc.

- *gandhaḥ* (0)
  * smell

    E.g. *sugandhaḥ, durgandhaḥ* etc.
- *parimāṇaḥ* (0)
  * measurements

    E.g. alpam, anekam etc.
- *śabdaḥ* (2)
  * sound

    E.g. *akṣaram, hastigarjanam* etc.
- *buddhiḥ* (0)
  * intelligence

    E.g. *buddhiḥ, jñānam* etc.
- *adṛṣṭam* (0)
  * unforeseen merit or demerit

    E.g. *dharmaḥ, adharmaḥ* etc.
- *mānasikabhāvaḥ* (0)
  * mental condition

    E.g. *icchā, spṛhā* etc.

The sub-classes of śabdaḥ

The node *śabda* is divided into two viz. *varṇātmakaḥ* and *dhvanyātmakaḥ*. *Dhvanyātmakaḥ* marks all the instrumental sounds and *varṇātmakaḥ* marks articulate sounds like letters etc.. *Varṇātmakaḥ* is divided into two viz. *apauruṣeyam* and *pauruṣeyam*. The node *apauruṣeyam* marks the divine knowledge which is available between the vedic time and the purāṇic time. The *pauruṣeyam* node represents the origins of other knowledge. The classification is given below.

- *varṇātmakaḥ* (2)
  - articulate sounds

      * E.g. *akṣaram* etc.

- *dhvanyātmakaḥ* (0)
  - instumental sounds
    * E.g. *vīṇānādaḥ, tālaḥ* etc.

The sub-classes of varṇātmakaḥ

- *apauruṣeyam* (0)
  - divine knowledge
    * E.g. *vedāḥ, mantraḥ* etc.
- *pauruṣeyam* (0)
  - the knowledge which are created by man
    * E.g. *vyākaraṇa, nyāya* etc.

Kriyā, sāmānya and abhāva classification

In *vaiśeṣika* ontology, *kriyā* is classified into five. Since *Amarakośa* does not have any instance of verbs, we did not require this class. *Sāmānya* has two divisions in *vaiśeṣika* ontology named *param* and *aparam*. In this scheme also there are two sub-classes named *jātiḥ* and *avasthā*. *Jātiḥ* is the permanent property in all things but *avasthā* is the concurrent property. All the words indicating *abhāva*s are classified as *abhāva*s :- Eg. *vṛṣṭyabhāvaḥ, vidhyābhāvaḥ* etc..

6.4.2 Upādhiḥ and it's classification

The *upādhi* nodes are taken on the basis of our necessity. *Upādhi* is divided into sixteen subclasses. Some nodes have sub-divisions also. This *upādhi* scheme is extendable as per our necessity, because according to nyaya anything may became *upādhi*. *Upādhi* nodes are - *avayavaḥ, samūhaḥ, vṛttiḥ, khādyam, nāma, vāhanam, vastram, upakaraṇam, ābharaṇam, ratnam, dhanam, cihnam, indriyam, kāraṇam, ākṛtiḥ, śaktiḥ*. The *Upādhi* classification is given in the figure 6.6. The classification, describing each node with an example is given below. The number of sub-nodes also shown

in bracket against each node.

1. Upādhi classification

- *avayava* (0)
  - part of a living body
    - * E.g. *phaṇaḥ, śākhā, pādaḥ* etc..
- *samūhaḥ* (0)
  - groups
    - * E.g. *tṛṇasamūhaḥ, jantusamūhaḥ, paśusaṅghaḥ* etc..
- *vṛtti* (0)
  - profession
    - * E.g. *ābhīrī, vaidyaḥ, adhyāpakaḥ* etc..
- *khādyam* (3)
  - eatable things
    - * E.g. *grāsaḥ, bhuktocciṣṭam*etc..
- *nāma* (0)
  - names of the individuals
    - * E.g. *bṛhaspatiḥ, śukrācāryaḥ, gaṅgā* etc..
- *Vāhanam* (1)
  - vehicles
    - * E.g. *krīḍāradhaḥ, śakaṭikā, naukā* etc..
- *vastram* (0)
  - cloths
    - * E.g. *dhautakauśeyam, paṭṭavastram, uparivastram* etc..
- *upakaraṇam* (4)

- instruments
  - E.g. *kamaṇḍaluḥ, śarādhāraḥ, mūṣā* etc..

- *ābharaṇam* (0)
  - ornaments
    - E.g. *śiromaṇiḥ, kirīṭam, karṇābharaṇam* etc..

- *ratnam* (0)
  - gems
    - E.g. *maratakamaṇiḥ, pravālamaṇiḥ, hāramadhyamaṇiḥ* etc..

- *dhanam* (0)
  - different types of prizes
    - E.g. *baliḥ, śulkaḥ, mūladhanam, rajatarūpyakam* etc..

- *cihnam* (0)
  - signs
    - E.g. *rājacihnam, puṇḍram, viṣṇulāñcanam* etc..

- *indriyam* (0)
  - organs
    - E.g. *śabdādīndriyam, cakṣurādīndriyam, pāyvādīndriyam* etc..

- *kāraṇam* (0)
  - cause
    - E.g. *mukhyakāraṇam, sādhakatamam* etc..

- *ākṛtiḥ* (0)
  - shape
    - E.g. *vṛttam, golaḥ* etc..

- *śaktiḥ* (0)

  - power
    * E.g. *rājaśaktiḥ, siddhiḥ* etc..

1.1. The sub-classes of Khādyam

The node *khādyam* is divided into three viz. *prākṛtikakhādyam, vikṛtikakhādyam* and *pānīyam*. The node *pānīyam* has a sub-node named *alaukikapānīyam*. The classification is given below.

- *prākṛtikakhādyam* (0)
  - natural foods
    * E.g. *madhuḥ, yavaḥ, vrīhībhedaḥ* etc..
- *vikṛtikakhādyam* (0)
  - modified foods
    * E.g. *auṣadham, lavaṇam, pṛdhukaḥ* etc..
- *pānīyam* (1)
  - watery foods
    * E.g. *dugdham, surā, kvādhaviśeṣaḥ* etc..

1.1.1 The sub-class of Pānīyam

- *Alaukikapānīyam* (0)
  - heavenly watery food
    * E.g. *amṛtam* etc..

1.2 The sub-class of Vāhanam

- *alaukikavāhanam* (0)
  - celestial vehicles
    * E.g. *devarathaḥ, kuberavimānam* etc..

1.3 The sub-classes of Upakaraṇam

- *āyudham* (0)

    - weapons
        * E.g. *śūlam, bāṇaḥ, halam* etc..

- *vādyopakaraṇam* (0)
    - musical instruments
        * E.g. *bherī, vīṇā, mṛdaṅgaḥ* etc..

- *gārhikopakaraṇam* (0)
    - house keepings
        * E.g. *gṛhasammārjanī, śayyā, paryaṅkaḥ* etc..

- *alaukikopakaraṇam* (0)
    - celestial weapons
        * E.g. *śivadhanuḥ, indrasya vajrāyudham* etc..

This ontology is emerged from *Amarakośa* classification. This needs to be studied further.

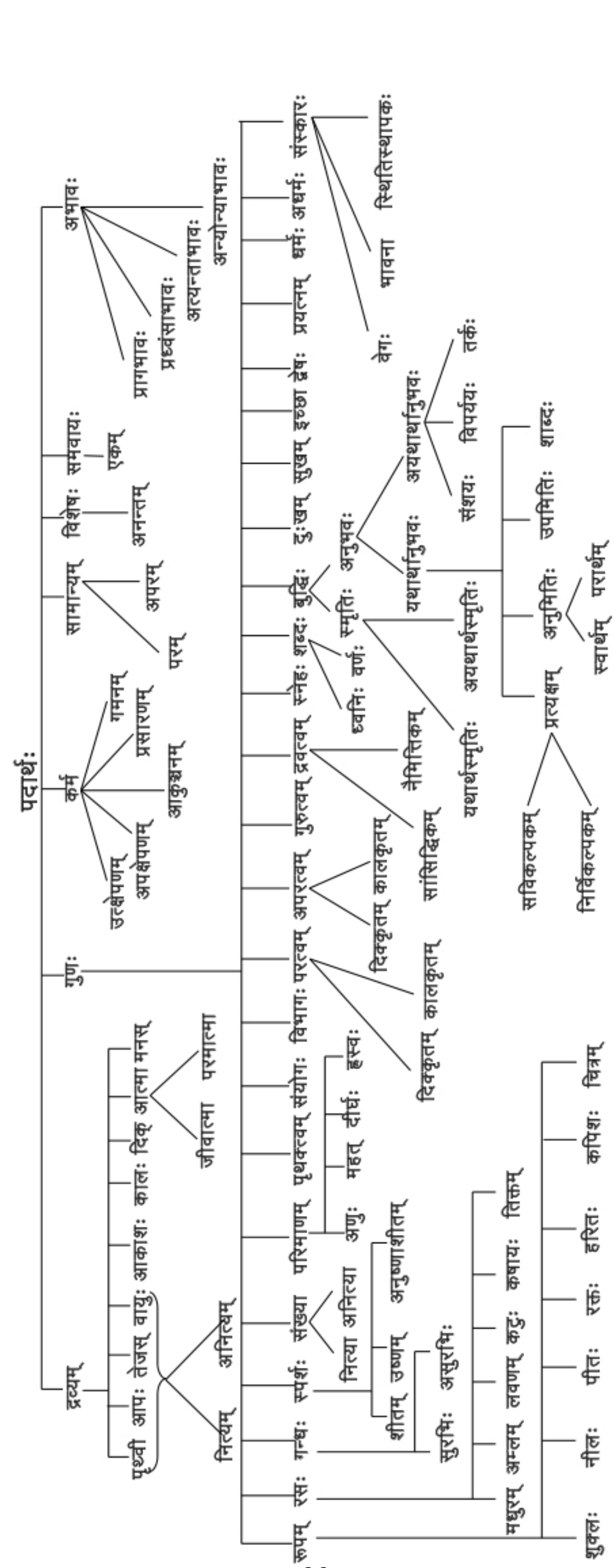


Figure 6.4: Vaiśeṣika Classification of existence

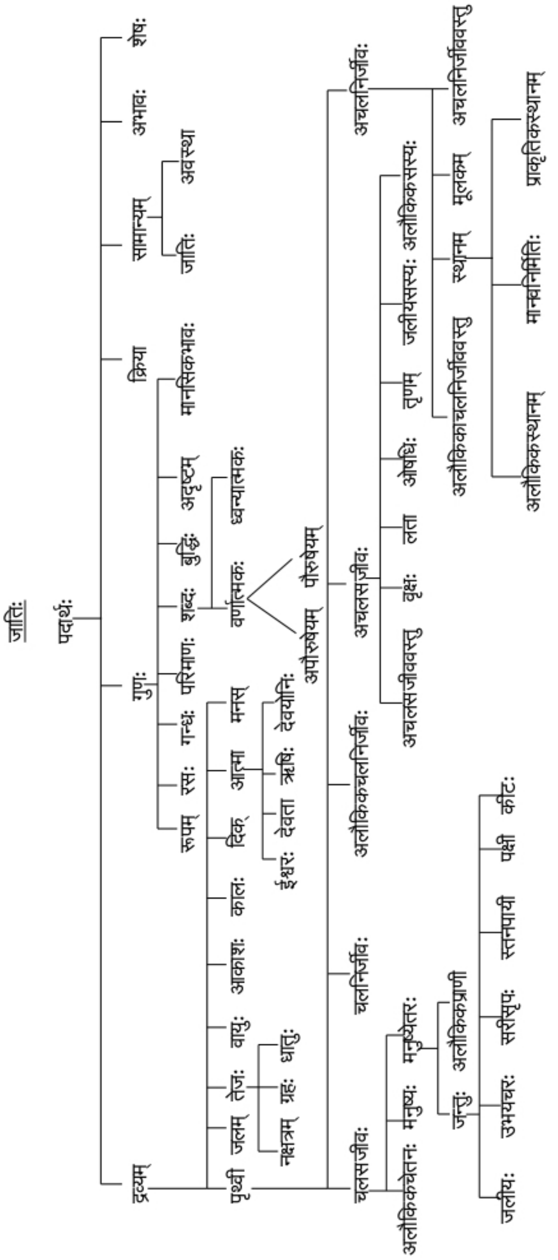


Figure 6.5: *jāti* chart

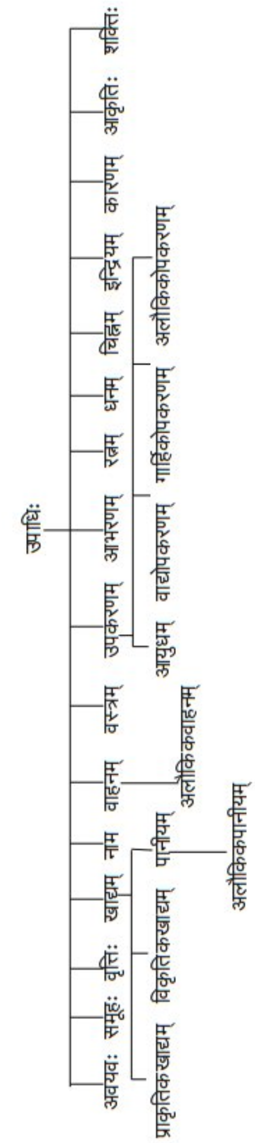


Figure 6.6: *upādhi* chart

Chapter 7

Amarakośajñānajālam

The *Amarakośajñānajālam* is developed as a web application. The application provides a search result of a query dynamically generated using the structured lexicon of the Amarakośa and the supplementary tables marking the relations.

The structured lexicon as well as the supplementary tables showing the explicit relations are simple ASCII text files. Sanskrit words are stored in a roman transliterated scheme, named WX notation (see Appendix-A). There are two advantages of storing the text in WX notation. Unicode for Devanagari mixes the phonemes with the syllables, making it unnatural to write the search expressions. But WX-notation being purely alphabetic, it is natural to write regular expressions and thus facilitates a lexicographer to use simple unix tools such as grep, sed, etc. for his day-to-day work of updating the knowledge-base. The second advantage, of course, is the size. The size of the tables in UTF-8 for Devanagari is more than 2 times, the corresponding files in roman transliteration such as WX notation.

7.1 Structured Lexicon

The main structured lexicon consists of synsets stored in the form of a set of records. Each record corresponds to a word in the Amarakośa (excluding the meta-language words). A record has five fields as described below.

7.1.1 Stem

Amarakośa lists words in nominative cases. However, we decided to go for the nominal stem instead of the nominative case word form. In case of feminine words, this field contains the feminine stem, i.e. the stem after adding a feminine suffix. In case of words from *nānārthavarga*, the polysemous word is entered in this field.

The reason for choosing nominal stem over the nominative case form is the ease in linking the *Amarakośa* words with the existing computational resources such as morphological generators and various e-lexicons, which typically expect a *prātipadikam* and not a *prathamānta* (ending in nominative case).

7.1.2 Amarakośa index

This field contains a reference to an entry in the Amarakośa, as a 5 tuple of numbers, separated by dots. The 5 numbers in the 5 tuple refer to the *kāṇḍa, varga, śloka, pāda* and the word number respectively. Table 7.1 shows a sample entry corresponding to the following śloka :-

स्वरव्ययं स्वर्गनाकस्त्रिदिवस्त्रिदशालयाः।
सुरलोको द्योदिवौ द्वे स्त्रियां क्लीबे त्रिविष्टपम्॥१.१.६॥

7.1.3 Liṅgam (gender)

This field contains gender of the stem. The gender of a word in a śloka is decided with the help of meta-language employed by Amarakośa. These are further cross checked with Devadatta Tiwari's *Devakośa Arthāt Amarakośaḥ* (Tiwari, 1989) and Colebrooke's commentary on Amarakośa (Colebrooke, 1808) when in doubt.

Sanskrit has 3 values for gender viz. masculine, feminine and neuter. Thus there are 8 possible combinations (an indeclinable is assigned no gender, and the adjectives are the ones which take all the three genders). In addition, Amarakośa also provides information about words that are always plural or dual by nature. Following combinations of gender, number information were found in the Amarakośa.

Word	**Reference**
svar	1.1.6.1.1
svarga	1.1.6.1.2
nāka	1.1.6.1.3
tridiva	1.1.6.1.4
tridaśālaya	1.1.6.1.5
suraloka	1.1.6.2.1
dyo	1.1.6.2.2
div	1.1.6.2.3
triviṣṭapa	1.1.6.2.4

Table 7.1: Words and references of the *svarga*-synset

- Indeclinable - (*avya.*)
- Feminine - (*strī.*)
- Masculine - (*puṃ.*)
- Neuter - (*napuṃ.*)
- Masculine and Feminine - (*strī-puṃ.*) [aśani[1]]
- Feminine and Neuter - (*strī-napuṃ.*) [uḍu[2]]
- Feminine dual - (*strī-dvi.*) [dyāvāpṛthvyau[3]]
- Feminine plural - (*strī-bahu.*) [apsaras[4]]
- Masculine and Neuter - (*puṃ-napuṃ.*) [daivatāni[5]]
- Masculine dual - (*puṃ-dvi.*) [nāsatyau[6]]
- Masculine plural - (*puṃ-bahu.*) [gṛhāḥ[7]]

[1] aśanirdvayoḥ (1.1.47)
[2] tārakāpyuḍu vā striyāṃ (1.3.21)
[3] dyāvāpṛthvyau (2.1.19)
[4] striyāṃ bahuṣvapsarasaḥ (1.1.52)
[5] daivatāni puṃsi vā (1.1.9)
[6] nāsatyāvaśvinau dasrāvāśvineyau ca tāvubhau (1.1.51)
[7] gṛhāḥ puṃsi ca bhūmnyeva (2.2.5)

- Neuter and indeclinable - (*napuṃ-avya.*) [apadiśaṃ[8]]
- Adjective - (*vi.*)

7.1.4 Vargaḥ

This field contains name of the varga, as given in the commentaries to which the entry belongs.

7.1.5 Head Word

The first four fields cover all the explicit information that can be easily extracted automatically. An important feature of Amarakośa is that it provides synonymous words. The marking of synonymous words is obvious only through the world knowledge or through the commentaries. To provide a handle to each set of synonymous words -- called as synset, we created a field termed as *Head Word* which provides a name to each synset. Thus these Head Words are unique and act as a reference ID for a synset. The total number of Head Words give us the total number of synsets in the Amarakośa. We denote the synset corresponding to a Head Word *W* by *Syn(W)*.

The choice of Head-Words is mainly guided by the *Bhānujidīkṣita*'s *Sudhā* commentary on *Amarakośa* (Pandit, 1915). When a better choice was available in the Malayalam commentary *Triveṇī* (Moosath, 1956) or *Pārameśvarī* (Moosath, 1914) or the Hindi commentary *Prabhā*, it was chosen. Table 7.2 shows an example of a śloka 2.5.5 converted to a structured table, and Figure 7.1 shows the search result of the *Amarakośajñānajālam* for the word śṛgāla. The Head-word has an entry *jaṃbhūkaḥ* which stands as a handle to represent the complete synset.

7.2 Marking of Various Relations

In this section we describe the structure of the database that marks various relations between synsets. Since a synset is uniquely represented by a head-word, we mark the relations between the head-words. Each record

[8] klībāvyayaṃ tvapadiśam (1.3.5)

Token	Reference	Gender	Varga-name	Head-Word
śivā	2.5.5.1.1	strī	siṃhādivargaḥ	jaṃbhūkaḥ
būrimāya	2.5.5.1.2	puṃ	siṃhādivargaḥ	jaṃbhūkaḥ
gomāyu	2.5.5.1.3	puṃ	siṃhādivargaḥ	jaṃbhūkaḥ
mṛgadūrtaka	2.5.5.1.4	puṃ	siṃhādivargaḥ	jaṃbhūkaḥ
śṛgāla	2.5.5.2.1	puṃ	siṃhādivargaḥ	jaṃbhūkaḥ
vañjaka	2.5.5.2.2	puṃ	siṃhādivargaḥ	jaṃbhūkaḥ
kroṣṭu	2.5.5.2.3	puṃ	siṃhādivargaḥ	jaṃbhūkaḥ
pheru	2.5.5.2.4	puṃ	siṃhādivargaḥ	jaṃbhūkaḥ
pherava	2.5.5.2.5	puṃ	siṃhādivargaḥ	jaṃbhūkaḥ
jaṃbuka	2.5.5.2.6	puṃ	siṃhādivargaḥ	jaṃbhūkaḥ

Table 7.2: Example of Head-Word

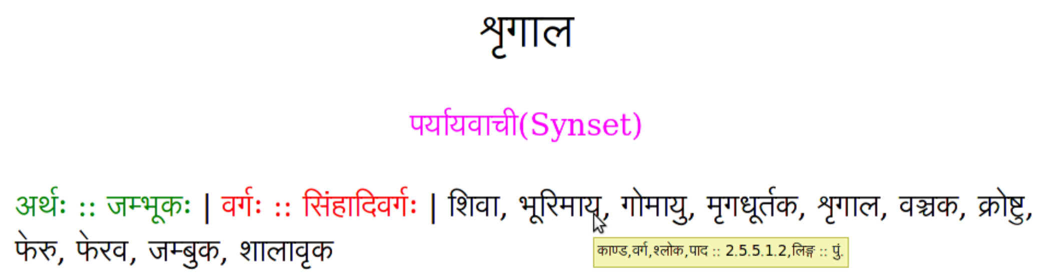


Figure 7.1: Example of a synset

corresponds to one synset ID. The first field of each record consists of the head-word which acts as a unique ID corresponding to the synset it represents. Remaining fields correspond to six relations the head-word has with other head-words. The six relations are *is_a_part_of* (*avayavāvayavī*), *is_a_kind_of* (*parāparājāti*), *janyajanaka*, *svasvāmi*, *ājīvikā*.

1. Is a part of (*avayavāvayavī*)
   This field marks *is a part of* relation. Let W be the synset-ID. Then this field will have an entry W' if the member of $SynW$ is a part of

Head-Word W	part (अवयव)-of W
rātrimadhyaḥ	rātriḥ
rātriprārambhaḥ	rātriḥ

Table 7.3: Example of is-a-part relation

Head-Word W	kind (*parāparājāti*) of W
gaṅgā	nadī
yamunā	nadī
narmadā	nadī

Table 7.4: Example of is_a_kind_of relations

member of $SynW'$ (See Table 7.3).

For example,
Syn(रात्रिः) = शर्वरी, क्षणदा, क्षपा, निशा, निशीथिनी, रजनी, रात्रि, विभावरी, तमस्विनी, तमी, त्रियामा, यामिनी, नक्तम्, दोषा, वसति, श्यामा.
and
Syn(रात्रिमध्यः) = अर्धरात्र, निशीथ.

Now, अर्धरात्र, निशीथ are part of निशा, रजनी, रात्रि, etc.. Hence रात्रिमध्यः is marked to be is_a_part_of (अवयव of) रात्रिः

Similarly प्रदोष, रजनीमुख (Syn (रात्रिप्रारम्भः)) are also part of निशा, रजनी, रात्रि, etc.. Hence रात्रिप्रारम्भः, where Syn (रात्रिप्रारम्भः)= प्रदोष, रजनीमुख also bears a part_of relation with रात्रिः.

2. Is a kind of (*parāparājāti*)
   This field marks *is a kind of* relation. The entry contains the Head Word W' such that synset ID W bears a relation of *is a kind of* with W'. The hypernymy and hyponymy relation can be extracted using this field. Table 7.4 shows some sample entries.

3. Parent-child relation (*janyajanakabhāva*)
   This field marks the relation of parent-child (*janyajanakabhāva*). (see

Head-Word W	Child (*janya*) of W
indraḥ	jayantaḥ
brahmā	sanatkumāraḥ
śivaḥ	gaṇeśaḥ

Table 7.5: Example of Janya-janaka relation

Table 7.5) Where Syn (जयन्तः) = पाकशासनी, जयन्त.
and
Syn (इन्द्रः) = इन्द्र, बिडौजस्, मघवन्, मरुत्वत्, पाकशासन, सुनासीर, वृद्धश्रवस्, पुरन्दर, पुरुहूत, जिष्णु, लेखर्षभ, शक्र, शतमन्यु, दिवस्पति, वृषन्, वृत्रहन्, गोत्रभिद्, सुत्रामन्, वासव, वज्रिन्, बलाराति, शचीपति, सुरपति, वास्तोष्पति, हरिहय, जम्भभेदिन्, नमुचिसूदन, स्वाराज्, मेघवाहन, सङ्क्रन्दन, तुराषा, दुश्च्यवन, आखण्डल, ऋभुक्षिन्, सहस्राक्ष, कौशिक, घनाघन, पर्जन्य, हरि.

Syn (सनत्कुमारः) = सनत्कुमार, वैधात्र
and
Syn (ब्रह्मा) = आत्मभू, ब्रह्मन्, चतुरानन, हिरण्यगर्भ, लोकेश, परमेष्ठिन्, पितामह, सुरज्येष्ठ, स्वयम्भू, अब्जयोनि, अण्डज, हंसवाहन, कमलासन, कमलोद्भव, नाभिजन्मन्, निधन, प्रजापति, पूर्व, रजोमूर्तिन्, सत्यक, सदानन्द, स्रष्टृ, वेधस्, विरिञ्चि, विश्वसृज्, विधातृ, विधि, धातृ, द्रुहिण, क, आत्मन्, शम्भु.

4. Husband-wife relation (*patipatnībhāva*)
This field marks the husband-wife relation, as shown below. (see Table 7.6) Where Syn(लक्ष्मी) = भार्गवी, हरिप्रिया, इन्दिरा, कमला, क्षीरसागरकन्यका, क्षीरोदतनया, लक्ष्मी, लोकजननी, लोकमातृ, मा, पद्मा, पद्मालया, रमा, श्री, वृषाकपायी.
and
Syn(विष्णुः) = हृषीकेश, केशव, कृष्ण, माधव, नारायण, स्वभू, वैकुण्ठ, विष्णु, विष्टरश्रवस्, दामोदर, अच्युत, गरुडध्वज, गोविन्द, जनार्दन, पीताम्बर, पुण्डरीकाक्ष, शार्ङ्गिन्, विष्वक्सेन, दैत्यारि, चक्रपाणि, चतुर्भुज, इन्द्रावरज, मधुरिपु, पद्मनाभ, उपेन्द्र, वासुदेव, त्रिविक्रम, अधोक्षज, बलिध्वंसिन्, कंसाराति, पुरुषोत्तम, शौरि, श्रीपति, वनमालिन्, देवकीनन्दन, जलशायिन्, कैटभजित्, मुकुन्द, मुरमर्दन, नरकान्तक, पुराणपुरुष, श्रीवत्सलाञ्छन, विश्वम्भर, विश्वरूप, विधु, यज्ञपुरुष, लक्ष्मीपति, मुरारि, अज, अजित, अव्यक्त, वृषाकपि, बभ्रु, हरि, वेधस्.

Head-Word W	**Husband (पति) of W**
lakṣmī	viṣṇuḥ
pārvatī	śivaḥ
lopāmudrā	agastyaḥ

Table 7.6: Example of *patipatnībhāva* relation

Head-Word W	**master (स्वामि) of W**
viṣṇoḥ mantriḥ	viṣṇuḥ
viṣṇoḥ sārathiḥ	viṣṇuḥ
garuḍaḥ	viṣṇuḥ

Table 7.7: Example of *svasvāmi* relation

5. Master-possession relation (*svasvāmibhāva*)
   This field marks the master-possession or *svasvāmibhāva* relation as shown below: (see Table 7.7)

6. Livelihood (*ājīvikā*)
   This field marks the livelihood relation between two syn-sets. For example, the synset with Head Word मत्स्य is (अण्डज, झष, मत्स्य, मीन, पृथुरोमन्, शकुली, वैसारिण, विसार, अनिमिष) denotes objects which act as a livelihood for the objects expressed through the concept of धीवर, and hence the livelihood for the objects belonging to the synset धीवर is marked as a मत्स्य. (see Table 7.8)

Head-Word W	**Livelihood (*ājīvikā*) of W**
dhīvaraḥ	matsyaḥ
nartakī	nṛtyam
nāvikaḥ	naukā
sevakaḥ	sevā

Table 7.8: Example of *ājīvikā* relation

No.	Relation	Headwords	Words
1	is_a_kind_of	2239	6807
2	is_a_part_of	560	1654
3	janya-janaka	17	193
4	sva-svāmī	36	122
5	ājīvikā	30	106
6	pati-patnī	25	105

Table 7.9: Relational statistics

7.3 Quantitative analysis

For every headword, one or more of the relations as specified above are marked. As was expected, the hierarchical relations viz. is_a_kind_of and is_a_part_of appear prominently than the associative relations. The occurrence of various relations in terms of Head-Words and all the words belonging to the synsets denoted by these head words is shown in Table 7.9.

7.4 Implementation

From the structured lexicon table and the table of relations we build data bases using the built-in dbm engines of unix. These dbm engines use hashing techniques to enable fast retrieval of the data by key.

Following three hash tables are built from the structured lexicon.

a) Head-word hash
where Key=stem and Value=head-word

b) Synset hash
with Key=head-word and Value=synset

c) Word-info hash
generated by Key=stem and Value=word-index and gender

Head-word	Jātiḥ	Upādhiḥ
Sarpaḥ	Sarīsṛpaḥ	-
Viṣṇu-lāñcanam	-	cihnam
Maṅgalaḥ	grahaḥ	nāma

Table 7.10: Example of ontological representation data

From the table of relations, corresponding to each relation R, we built a hash table which returns the associates a head-Word W with another head-word W', if W' is related to W by relation R

7.5 Ontological Representation Table

The ontological representation nodes which correspond to the Head-word are marked as records, each record carrying one synset ID. The first field of each record consists of the synset ID, and remaining two fields correspond to the ontological nodes.

Ontological nodes are marked according to the chart which is prepared for ontological representation. This chart has two parts, the first part is named as *jātiḥ* and the second part is named as *upādhiḥ* . Second field of each record is reserved for marking the *jātiḥ* node and the third field is for marking the *upādhiḥ* node. Some of the records have both the second and the third fields are filled, but some times one of this may be empty. Here are some entries. (See the Table 7.10)

The detailed discussion about Ontological Representation scheme is available in the chapter 6.

7.5.1 Ontological Representation Scheme

The ontological representation scheme is recorded as a text file, which has two fields. Both of these fields contain ontological nodes. The first field has

Sub-node	Super-node
Nakṣtram	Tejaḥ
Grahaḥ	Tejaḥ
Dhātuḥ	Tejaḥ
Akāśaḥ	Dravyam
Dik	Dravyam
Ātmā	Dravyam

Table 7.11: Example of ontological representation scheme

the main node and the second field has its parent node. Some example are given in the Table 7.11.

Using a simple 'perl' program one can extract the ontological tree by traversing the table recursively until one reaches the root node. For example :-

=> Ātmā
  => Dravyam
    => Padārthaḥ

In this example the node *ātmā* is the sub-node of the node *dravyam* and the node *dravyam* is the sub-node of the node *padārthaḥ*. The node *padārthaḥ* is always the end node of the *jātiḥ* classification.

The *upādhiḥ* chart dose not follow a tree structure like *jātiḥ* . Some times it may end in the single node.

7.6 Web application

Amarakośajñānajāla is presented as a web application. Web application is an application which uses web browser as a client.

Amarakośajñānajāla is developed with 'apache' web server and 'perl' for CGI script. User submits a query as a word and a relation, machine produces all the words related to the given word by the chosen relation. The word here may be either a stem or an inflected word form. In the case of inflected word form, machine consults the morphological analyser to get the stem. Figures in Appendix-C give sample results of queries for different word-relation combinations. When a cursor is placed on a word a tool tip shows its word-index and gender (as shown in Figure 7.1.). The web application works as shown in Figure 7.2.

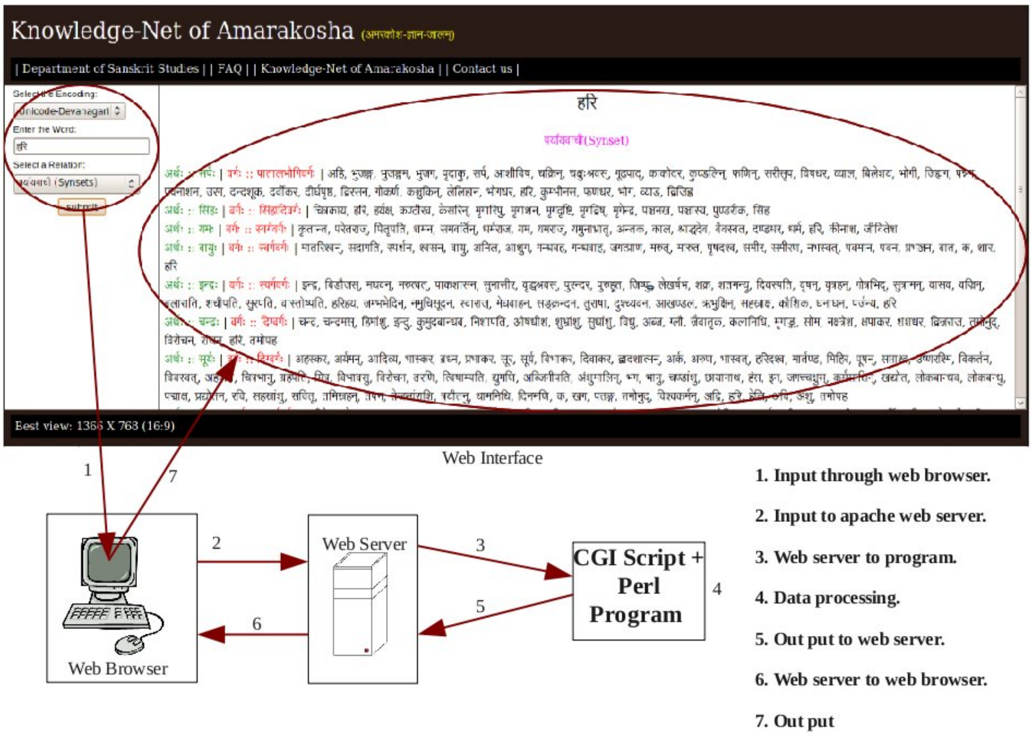


Figure 7.2: Web application

We give below a brief introduction to the 'apache' web server, and 'perl' as a programming language as well as a scripting language for writing CGI scripts.

7.6.1 Web Server : Apache

Web server is a mediator of the programs and web pages. "A web server can be referred to as either the hardware (the computer) or the software (the computer application) that helps to deliver content that can be accessed through the internet"[9]. Collection of programs which is available in a computer can call as web server. A web server provides basic HTTP protocol processing, web document retrieval.

Apache

Apache is generally recognized as the world's most popular Web server (HTTP server). Originally designed for Unix servers, the Apache Web server has been ported to Windows and other network operating systems (NOS). The name "Apache" derives from the word "patchy" that the Apache developers used to describe early versions of their software. The Apache Web server provides a full range of Web server features, including CGI, SSL, and virtual domains. Apache also supports plug-in modules for extensibility. Apache is reliable, free, and relatively easy to configure. Apache is free software distributed by the Apache Software Foundation. The Apache Software Foundation promotes various free and open source advanced Web technologies[10].

7.6.2 Programming language

Programming language is an artificial language which is created for performing some computer applications. It is an intermediator between men and machines. It helps men to create machine as a tool, to reduce the workload. A computer executes a sequence of instructions, in order to perform some task. These sequence of instructions should perform in an order. This order in known as algorithm. The result of expressing the algorithm in a programming language is called a program. The process of writing the algorithm using a programming language is called programming. Lots of Programming languages are available, like Java, C, C++, etc.

[9]http://en.wikipedia.org/wiki/Web_server, 13-01-2011
[10]http://compnetworking.about.com/cs/webservers/g/bldef_apache.htm

Perl

Perl is an acronym of "Practical Extraction and Report Language". It was created in 1986 by Larry Wall. Perl is a very easy and flexible language for linguistic performances. It is the popular choice due to its pattern matching capability, and its availability on many platforms (UNIX, Win32, Macintosh).

7.6.3 Server side scripting : CGI

Server-side scripting is a web server technology in which a user's request is fulfilled by running a script directly on the web server to generate dynamic web pages. It is usually used to provide interactive web sites that interface to databases or other data stores.

CGI Script

CGI is an abbreviation of Common Gateway Interface. It is an external gateway application. It is a specification for transferring information between a web server and programs. A CGI program is any program designed to accept and return data that conforms to the CGI specification. The program could be written in any programming language, including C, Perl, Java, or Visual Basic etc.. CGI scripts are referred to CGI applications/programs that are written in scripting language such as Perl, PHP, Shell. CGI language consideration are ease of text manipulation, ease to interface with other software libraries and utilities, and ease to access environment variables.

Chapter 8

Amarakośa and Hindi WordNet : Synset Comparisons

The structure, used by Amarasimha for creating *Amarakośa*, is a relational model, as is obvious from the fifth chapter. He uses a hierarchical structure for arranging kāṇḍas in *Amarakośa*. The examples discussed there in show the varied relations used in *Amarakośa*.

WordNet[1] -the electronic lexical database- is also build up on relations. So it is natural to compare the structure of *Amarakośa* with WordNet, because of this common feature. The main difference between WordNet and *Amarakośa* is, WordNet handles both semantic and lexical relations, but *Amarakośa* handles only semantic relations. Also *Amarakośa* deals only with nouns, but the WordNet deals with four parts of speech viz. noun, verb, adjective and adverb.

Hindi WordNet is the first WordNet for an Indian language. It is developed by a team from Center For Indian Languages Technology, IIT Bombay under the guidance of Pushpak Bhattacarya. This is the lexical network of Hindi words with semantic and lexical relations like other WordNets.

Hindi is a language derived from Sanskrit. Hindi has a lot of "tatsama" words, which are directly borrowed from Sanskrit. So a comparison of *Amarakośa* synsets with the Hindi synsets may give an insight into the

[1]http://wordnetweb.princeton.edu/perl/webwn

meaning shifts in borrowing.

Further, if found suitable, the association of synsets from Hindi WordNet and Amarakośa can be used to borrow various relations between these two, such as Ontology, Hypernym, Hyponym, Meronym, Holonym associated with the Hindi WordNet into Sanskrit.

To illustrate the idea, we give an example. The word *patra* in *Amarakośa* has three senses viz. leaf, bird's wing and vehicle. In this the first sense 'leaf' has the following synset :-

{छद, छदन, पलाश, पर्ण, पत्र, दल}

Hindi WordNet has this same sense and the synset is as below :-

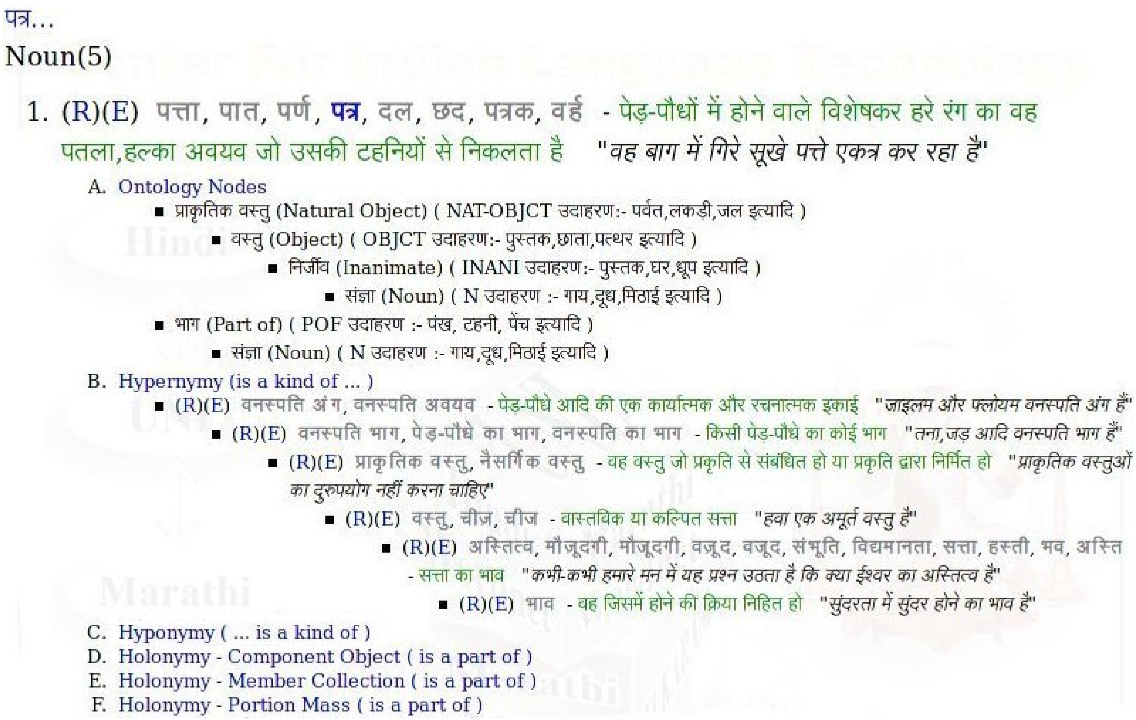
{पत्ता, पात, पर्ण, पत्र, दल, छद, पत्रक, वर्ह}

In this example most of the words which are in the synsets of Hindi WordNet and *Amarakośa* are the same. Figure 8.1 is the output of the word *patra* in Hindi WordNet.

This output consists of the hindi synset, gloss, example, Ontology nodes, Hypernymy, Hyponymy, different types of holonymies etc.. All these properties will credit to *Amarakośa* synset, if it is linked to Hindi WN. Thus a Sanskrit scholar who refers to *Amarakośa* will get all this extra informations for free. So linking between Hindi WordNet and *Amarakośa* is very much useful.

8.1 Comparison between Hindi WordNet and Amarakośa

For linking of Hindi WordNet with *Amarakośa* we should map, *Amarakośa*'s synset with Hindi WordNet's synset first. We used Hindi WordNet 1.1 dated December 12, 2007, which had 27,879 synsets. To find out the usability/adaptability of HWN for linking them with the *Amarakośa* synsets and further for extending the Sanskrit synsets, we compared the synsets that



पत्र...
Noun(5)

1. (R)(E) पत्ता, पात, पर्ण, **पत्र**, दल, छद, पत्रक, वर्ह - पेड़-पौधों में होने वाले विशेषकर हरे रंग का वह पतला,हल्का अवयव जो उसकी टहनियों से निकलता है *"वह बाग में गिरे सूखे पत्ते एकत्र कर रहा है"*
   A. Ontology Nodes
      - प्राकृतिक वस्तु (Natural Object) (NAT-OBJCT उदाहरण:- पर्वत,लकड़ी,जल इत्यादि)
        - वस्तु (Object) (OBJCT उदाहरण:- पुस्तक,छाता,पत्थर इत्यादि)
          - निर्जीव (Inanimate) (INANI उदाहरण:- पुस्तक,घर,धूप इत्यादि)
            - संज्ञा (Noun) (N उदाहरण :- गाय,दूध,मिठाई इत्यादि)
      - भाग (Part of) (POF उदाहरण :- पंख, टहनी, पेंच इत्यादि)
        - संज्ञा (Noun) (N उदाहरण :- गाय,दूध,मिठाई इत्यादि)
   B. Hypernymy (is a kind of ...)
      - (R)(E) वनस्पति अंग, वनस्पति अवयव - पेड़-पौधे आदि की एक कार्यात्मक और रचनात्मक इकाई *"जाइलम और फ्लोयम वनस्पति अंग हैं"*
        - (R)(E) वनस्पति भाग, पेड़-पौधे का भाग, वनस्पति का भाग - किसी पेड़-पौधे का कोई भाग *"तना,जड़ आदि वनस्पति भाग हैं"*
          - (R)(E) प्राकृतिक वस्तु, नैसर्गिक वस्तु - वह वस्तु जो प्रकृति से संबंधित हो या प्रकृति द्वारा निर्मित हो *"प्राकृतिक वस्तुओं का दुरुपयोग नहीं करना चाहिए"*
            - (R)(E) वस्तु, चीज़, चीज - वास्तविक या कल्पित सत्ता *"हवा एक अमूर्त वस्तु है"*
              - (R)(E) अस्तित्व, मौजूदगी, मौजूदगी, वज़ूद, वजूद, संभूति, विद्यमानता, सत्ता, हस्ती, भव, अस्ति - सत्ता का भाव *"कभी-कभी हमारे मन में यह प्रश्न उठता है कि क्या ईश्वर का अस्तित्व है"*
                - (R)(E) भाव - वह जिसमें होने की क्रिया निहित हो *"सुंदरता में सुंदर होने का भाव है"*
   C. Hyponymy (... is a kind of)
   D. Holonymy - Component Object (is a part of)
   E. Holonymy - Member Collection (is a part of)
   F. Holonymy - Portion Mass (is a part of)

Figure 8.1: HWN out put of the word *patra*

are common to both HWN and *Amarakośa*. We used simple unix utilities such as grep and compared the extracted synsets manually to check for similarities at the level of concept and at the level of membership of the words.

8.1.1 Hindi WordNet Database

The Hindi WN database consisted of 27,879 records. Each record had four fields viz. and ID, Synset, Concept associated with it and an example.

Sample entry

ID	00002061
SYN	शंकर, शिव, शङ्कर, महादेव, आशुतोष, कैलाश नाथ, त्रिपुरारि, त्रिपुरारी, भोलेनाथ, विश्वनाथ, महेश, भोला, भोलानाथ, पिनाकी, जटाधारी, हर,

	पिनाकपाणि, देवेश्वर, अनंगरि, अनर्थनाशी, अन्नपति, शंभु, शम्भु, रुद्र, त्र्यक्ष, त्र्यंबक, त्र्यम्बक, सुप्रतीक, गिरिनाथ, भगाली, सतीश, अबलाबल, अब्जवाहन, विद्वत्, राकेश, जटामाली, महार्णव, वीरेश, वीरेश्वर, शारंगपाणि, शारंगपानि, नागी, अंड, अंधकारि, अंबरीष, अक्षमाली, अघोरनाथ, अनंगारि, अयोनिज, अरिंदम, अर्घेश्वर, अहिमाली, इंदुशेखर, इन्दुशेखर, उग्रधन्वा, उमाकान्त, उमाकांत, उमेश, कपालपाणि, कपाली, कामारि, कालेश, काशीनाथ, कैलाशनाथ, गंगाधर, गिरीश, गौरीश, चंद्रशेखर, चन्द्रशेखर, तारकेश्वर, त्रिपुरांतक, नंदिकेश्वर, नीलग्रीव, परंजय, भवेश, भूतनाथ, भूतेश, भुवनेश, मंगलेश, महेश्वर, मृत्युंजय, योगीश, विरुपाक्ष, विरोचन, वृषभकेतु, अम्बरीष, वैद्यनाथ, व्योमकेश, पंचानन, शशिधर, नदीधर, भूतचारी, त्रिनेत्र, शशिभूषण, वसुप्रद
CONCEPT	एक सृष्टिनाशक हिन्दू देवता
EX	"शिव की पूजा लिंग के रूप में प्रचलित है"

8.1.2 Amarakośa synset

Amarakośa database consisted of 4,053 records. Each record had two fields SYNSET-head-word and the synset.
For example :

Head Word	शिवः
Synset	चन्द्रशेखर, ईश, ईशान, ईश्वर, महेश्वर, पशुपति, शम्भु, शङ्कर, शर्व, शिव, शूलिन्, भूतेश, गिरिश, गिरीश, खण्डपरशु, कृत्तिवासस्, मृड, मृत्युञ्जय, पिनाकिन्, प्रमथाधिप, कपालभृत्, कपर्दिन्, महादेव, शितिकण्ठ, श्रीकण्ठ, उग्र, वामदेव, विरूपाक्ष, त्रिलोचन, भर्ग, हर, कृशानुरेतस्, नीललोहित, सर्वज्ञ, स्मरहर, त्रिपुरान्तक, त्र्यम्बक, धूर्जटि, अहिर्बुध्न्य, अन्धकरिपु, अष्टमूर्ति, भव, भीम, गङ्गाधर, गजारि, क्रतुध्वंसिन्, महानट, रुद्र, स्थाणु, उमापति, वृषध्वज, व्योमकेश, अज, शिपिविष्ट, नीलकण्ठ, वृषाकपि

8.1.3 Comparison and result

Amarakośa has 4,053 synsets. We first searched for synsets with similar concepts in HWN by using simple grep utility that brings in all synsets covering the given word. Then manually we checked whether the HWN synset matches with the corresponding *Amarakośa*'s synset. We found

that in 1,554 cases, the synsets matched. But in 2,463, they did not. The differences in the un-matched synsets may be attributed to one or more of the following reasons.

8.2 Semantic changes

Over a period of time, the word meanings undergo changes due to various factors such as interaction/contacts with other cultural groups, languages, changes in societal structure and norms, etc. According to the speaker's or listener's intension the meaning of a word may change. The meaning-evolution may be classified into three broad categories viz. saṁkoca(shrinking) vistāra(expansion) and ādeśa(imposition)(Kapil Dvivedi, 2008).

J.L. Kamboj discusses, the causes of semantic changes, in his book named *"Semantic Change in Sanskrit"*, the cause may be linguistic or extra-linguistic, and he divides extra-linguistic causes into four major classes. Those are :-

- Semantic changes due to religious changes
- Semantic changes due to social cultural and economic changes
- Semantic changes due to geographical conditions
- Phsychological causes

Linguistic causes are divided into six major classes. Those are :-

- Semantic changes due to phonemic changes
- Influence of foreign language
- Re-borrowing
- Need for a new name
- Re-motivation
- Analogy

According to him these are the main causes. Kapil Deva Dvivedi explains cuases of semantic changes in three major divisions as *arthasaṁkoca, arthavikāsa* and *arthādeśa.*

Arthasaṁkoca
The etymological explanation of a word, may not denote all things which are the exact explanatories. E.g. *go*, "the thing which is moving" is the etymological meaning. That means, which ever things are moving all those can be refferred to *go* in Sanskrit. But now the word *go* is famous only in the meaning of 'cow'. The meaning is reduced from the all moving things to cow. This phenomena is known as *arthasaṁkoca* or shrinking of word meaning. The words, which have *rūḍi* meaning come under this category.

Arthavistāra
Some part of the meaning gets expanded and it shows the meaning of the word itself and the nearest meaning also. E.g. *pravīṇa*, originally meant "one who was skilled in playing a musical instrument called *vīṇā*". The word now comes to mean "a person skilled in anything". Here it lost the second part of the meaning. Most probably it shows the nearest meaning and some times it shows the etymological meaning also.

Arthādeśa
The etymological meaning of a word will impose up on a particular thing and this will act as main. E.g. *mṛga*, "animal" is the meaning. The meaning is now restricted in to "deer", and also have the main meaning quality, that is animality. Here the universality (animality) of *mṛga* is imposed in to a small group (deer group). This is called ādeśa or imposition of meaning.

Though Hindi is descended from Sanskrit, and bears a lot of commonality with original Sanskrit words with regards to the meanings, yet we see many instances where it has undergone various kinds of changes such as expansion, shrinking, etc. This is the main cause behind the un-matched synsets. In what follows give a detailed report on mismatches.

8.3 Report on various mismatches

We reporte below various kinds of mismatches between the synsets from Hindi WN and *Amarakośa*.

8.3.1 Conceptual Problems

Some times Amarasimha's concepts are totally different from HWN concept.

a) Asura and Rākṣasaḥ

According to *Amarakośa* "*asura*s" are the sons of *Diti*. *Rākṣasa*s are the followers of "*nirṛta*". But in Hindi WordNet both of these words are considered as one under the "ID 00003165". In this *nairṛta* and *daitya* both belong to the same synset. But according to *Amarakośa* both these words are members of different synsets.

ID	00003165
SYN	राक्षस, असुर, जातुधान, यातुधान, दैत्य, दैत, निशाचर, दानव, तमीचर, तमाचारी, नैरृत, नैऋत, अनुशर, अपदेवता, ध्वांतचर, ध्वान्तचर, कर्बर, देवारि, कर्बुर, कैकस, तमचर, निशिचर
CONCEPT	धर्म–ग्रंथों में मान्य वे दुष्ट आत्माएँ जो धर्म विरोधी कार्य करती हैं तथा देवताओं, ऋषियों आदि की शत्रु हैं
EX	"पुरातन काल में राक्षसों के डर से धर्म कार्य करना मुश्किल होता था"

b) Buddha and Śākya

According to *Amarakośa* "*Buddha*" and "*Śākya*" are the members of different synset. In *Amarakośa* "*Gautama, Māyādevīsuta, Śauddhodani*" are considered as "*Śākya*". The synset of *Buddha* is followed by the synset of *Śākya* as given below. Thus, Amarasimha considering *Śākya* as the incarnation of *Buddha* . Because of that he explained *Śākya* as *Māyādevīsuta* and *Śauddhodani*. In HWN *Gautama* and *Buddha* are considered as one, and therefore, naturally, *Māyādevī* is *Buddha*'s mother according to the ID 00017350.

Amarakośa synsets

Head Word	बुद्धः
Synset	भगवत्, बुद्ध, जिन, लोकजित्, मारजित्, समन्तभद्र, सर्वज्ञ, सुगत, तथागत, धर्मराज, अद्वयवादिन्, मुनि, मुनीन्द्र, षडभिज्ञ, शास्तृ, श्रीघन, विनायक, दशबल

and

Head Word	शाक्यः
Synset	शाक्यमुनि, अर्कबन्धु, गौतम, मायादेवीसुत, शाक्यसिंह, सर्वार्थसिद्ध, शौद्धोदनि

HWN synsets

ID	00002498
SYN	गौतम_बुद्ध, बुद्ध, गौतम, भगवान_बुद्ध, गौतमबुद्ध, तथागत
CONCEPT	बौद्ध धर्म के प्रवर्तक जिन्हें भगवान का अवतार माना जाता है
EX	"कुशीनगर गौतम बुद्ध की परिनिर्वाण स्थली है"

and

ID	00017350
SYN	माया _देवी, माया
CONCEPT	गौतम बुद्ध की माँ
EX	"माया देवी शुद्धोदन की पत्नी थीं"

8.3.2 Extended usage of the concept

Language, as is known, undergoes changes constantly. Hindi is an offshoot or a *prākṛta* language originated from Sanskrit. Over a period of time, some of the concepts got deviated or shifted from the original concepts. Further the influence of other languages such as Persian and Arabic over Hindi has added more shifts to Hindi. This is obvious from the following examples.

Svargaḥ

According to HWN *Svargaḥ* is having two synsets. ID 00007040 and ID 00006980. The first one is matching with the *Amarakośa* synsets concept which is indicating "heaven", but the second one is describing *Svargaḥ* as the place, which is attractive and pleasurable. The gloss which is given by HWN for the second sense is like this "मनमोहक और सुखदायक स्थान". This is an extended use of the concept heaven.

8.3.3 Shrink usage of the concept

In some cases the concepts from *Amarakośa* may shrink in to one synset in HWN synset. For example :-

ID	00004440
SYN	राजहंस, कलहंस, राज_मराल
CONCEPT	एक प्रकार का बड़ा हंस
EX	"ऐसा माना जाता है कि आज भी मानसरोवर में राजहंस मोती चुगने के लिए आते हैं"

According to *Amarakośa Kalahaṃsaḥ* and *Rājahaṃsaḥ* are members of different synset. *Kalahaṃsaḥ* means "drake" and *Rājahaṃsaḥ* means "verity of a goose whose leg and beak are in red color". But in HWN all these are members of a single synset.

Amarakośa synset

Head Word	कलहंसः
Synset	कलहंस, कादम्ब

and

Head Word	राजहंसः
Synset	राजहंस

8.3.4 Economy and expansion

Amarasimha uses a single synset for describing the plant and fruit. This is a kind of economy used by Amarasimha. He gives some rules in *vanauṣadhivarga* like this :-

द्विहीनं प्रसवे सर्वं हरीतक्यादयः स्त्रियाम्।
आश्वत्थवैणवप्लक्षनैयग्रोधैङ्गुदं फले॥ (2.4.18)
बार्हतं च फले जम्ब्वा जम्बूः स्त्री जम्बु जाम्बवम्।
पुष्पे जातिप्रभृतयः स्वलिङ्गाः व्रीहयः फले॥ (2.4.19)
विदार्याद्यास्तु मूलेऽपि पुष्पे क्लीबेऽपि पाटला।

The meaning is like this, the names of plants generally become neuter, to signify the produce of the plant viz. flower, leaf, fruit, tuber, root, etc.. Except *harītakyādi*[2], which are feminine denoting the fruit, etc. In these instances, derivatives are employed to signify the fruit, and in some other instances likewise, as *bailvam* etc.. Here the neuter, the derivative, and the irregular feminine, are all three employed. Jāti and certain others (as yūthikā, mallikā etc.) irregularly retain the original genders, to signify the flower of the plant, so do the names of corn and pulse, to signify the seed. And so do vidārī, and others (as Gambhārī, etc.) to denote the root, or the blossom, some add the fruit. here the neuter, and the original feminine gender, are both admissible, and even the masculine.

After this he starts giving the synonyms of plants. So we can extract the words which denote the parts of a palnt using these rules.

HWN created separate synset for both the plant and the fruit. For example :-

ID	00005618
SYN	हल्दी, हलदी, हरिद्रा, पीतिका
CONCEPT	एक पौधा जिसकी जड़ मसाले के काम आती है
EX	"समय पर सिंचाई न होने के कारण हल्दी सूख गई"

and

ID	00008329
SYN	हल्दी, हलदी, हरिद्रा, पीतिका
CONCEPT	एक पौधे की जड़ जो मसाले और रँगाई के काम में आती है
EX	"हल्दी एक रोग प्रतिरोधक औषध है"

[2] *harītakī, kośātakī, nakharañjanī, śaṣkandhī, dāḍī, doḍī, śvetapākī, arjunapākī, drākṣā, kālā, dhvākṣā, gabhīkā, kaṇḍakārikā, pippalī, ciṁpā and śephālikā*

We observe that the synsets of both plant and fruit are the same.

8.3.5 Diachronic changes

It means the changes of the word meaning in a span of time, because of cultural variations. In these cases there must be some difference between the meaning of a word in the Amarasmha's time and modern time. Example :-

a) Lāñchana

In this case the word *lāñchana* is used by Amarasimha in the meaning of *cihnam*. The synset is given below :-

Head Word	चिह्नम्
Synset	चिह्न, अङ्क, कलङ्क, लक्षण, लक्ष्मन्, लाञ्छन, लिङ्ग, निमित्त, पद, व्यञ्जन, प्रज्ञान

But in modern times it is changed in to a negative meaning, and also it is reflected in HWN. In HWN the word *lāñchana* has negative connotation. HWN synset is given below.

ID	00000178
SYN	लांछन, लांछना, कलंक, दाग़, दाग, आक्षेप, अपयश, अपवाद, कालिमा
CONCEPT	किसी पर लगाया जाने वाला दोष
EX	बिना सोचे समझे किसी के चरित्र पर लांछन लगाना ठीक नहीं है

b) Nūtanapatram and Nūtanāṇkuraḥ

Here in this case the concepts of *nūtanapatram* and *nūtanāṇkuraḥ* are shrinked in to one concept because of diachronic changes. The synsets are given below.

Amarakośa synset

Head Word	नूतनपत्रम्
Synset	किसलय, पल्लव

and

Head Word	नूतनाङ्कुरः
Synset	अभिनवोद्भिद्, अङ्कुर, प्रवाल

HWN synset

ID	00000643
SYN	कोंपल, कोपल, कल्ला, किसलय, किशलय, नव_पल्लव, नवपल्लव, नई पत्ती, मंजरी, पल्लव, किशल, प्रवाल
CONCEPT	नया निकला हुआ कोमल पत्ता
EX	"वह पेड़ से कोंपलें तोड़ रहा है"

8.4 Suggestions for HWN

There is a need to look at the synsets of HWN critically. While comparing the synsets with those of *Amarakośa praryāyapadā*s, we noticed the following errors.

8.4.1 Repetition of Synsets

In HWN some of the synsets have more than one entries as shown below.

First case

ID	00012253
SYN	गुग्गुल, गूगल, गूगुल
CONCEPT	एक काँटेदार पेड़ जिसका गोंद सुगंध के लिए जलाया जाता है
EX	"गुग्गुल का गोंद बहुत ही उपयोगी होता है

and

ID	00012404
SYN	गुग्गुल, गूगल, गूगुल
CONCEPT	एक काँटेदार पेड़ से प्राप्त गोंद जो सुगंध के लिए जलाया जाता है
EX	"उसने दुकान से गुग्गुल और लोहबान खरीदा"

Second case

ID	00001150
SYN	इंद्रियगम्य, इंद्रिय_गोचर, गोचर, इंद्रियग्राह्य, इन्द्रियगोचर, इंद्रियगोचर, प्रत्यक्ष, अपरोक्ष
CONCEPT	जिसका ज्ञान या अनुभव इंद्रियों से हो सके
EX	"दिखाई देनेवाली सभी वस्तुएँ इंद्रियगम्य हैं"

and

ID	00008046
SYN	गोचर
CONCEPT	जिसका ज्ञान इंद्रियों द्वारा हो सके
EX	"यह संसार गोचर है"

8.4.2 Wrong synset

ID	00002074
SYN	मन, चित्त, चित, मानस, दिल, जी, अंतःकरण, अन्तःकरण, ~~पेट, तबीयत, तबियत,~~ अंतर, अन्तर, ज़हन, जहन, जेहन, ज़ेहन, जिहन, ज़िहन, असु, अंतस्, अन्तस्
CONCEPT	प्राणियों में अनुभव, संकल्प–विकल्प, इच्छा, विचार आदि करनेवाली शक्ति
EX	"मन की चंचलता को दूर करना कठिन कार्य है / दूसरे के मन की बात कौन जान सकता है"

Here the words *peṭa, tabīyata, tabiyata* do not have the meaning described in the concept and hence these words should be removed from this synset.

8.4.3 Different Concepts but synset members are same

This is a problem which occur in the HWN itself. The problem is this, two synsets are almost same, but concepts are totally different.

ID	00022398
SYN	भृंगराज, भिंगराज, भिंगोरी, भिंगोरा, भृंगरज, भृङ्गराज, भृङ्गरज, भंगराज, भँगरा
CONCEPT	एक पक्षी
EX	"भृंगराज काले रंग का होता है"

and

ID	00022399
SYN	भृंगराज, भिंगराज, भिंगोरा, भँगरा, भँग, भृंगरज, भृङ्गराज, भृङ्गरज, भंगराज, भंगरैया
CONCEPT	एक वनस्पति जो बरसात में उगती है
EX	"काले फूल वाले भृंगराज के प्रयोग से सफेद बाल काले हो जाते हैं"

8.5 Conclusion

The comparison between HWN and *Amarakośa* showed that there is very little common between the two. That means, in order to enrich the *Amarakośa* synsets with various kinds of relations among them, one has to

provide these entries manually, which is a substantial task. Nevertheless this study was useful to link the Hindi synsets with those of *Amarakośa*, and it should be extended further to other Indian Languages as well. Such a study will also give a fair idea about how various languages have deviated from Sanskrit.

Further, the ontology used by HWN also differed from that of the *Vaiśeṣika* ontology. It was natural for us to follow *Vaiśeṣika* ontology and extend it further for the kind of task that is at hand rather than adapting some other ontology.

In the chapter on ontology, we discuss the concerns.

The second important aspect was that the various kinds of relations used by WordNet were not sufficient to describe the 'structure' of *Amarakośa* faithfully. Chapter five describes various kinds of relations implicitly marked in *Amarakośa*. We decided to make this in-built inherent information explicit, rather than just adapting/imposing WordNet structure on *Amarakośa*.

Chapter 9

Conclusion

9.1 Amarakośajñānajāla as a model for other kośas

The study of Amarakośa from a point of view of exploring the relations was undertaken to reveal the implicit knowledge and make it explicit. The resulting computational tool helps a Sanskrit reader to get a feel for various kinds of relations mentioned in the Amarakośa and thereby its richness as a knowledge source. The hierarchical relations such as is_a_part_of and is_a_kind_of will be of help in information extraction, while the associative relations help a reader to get the cultural knowledge.

Sanskrit has a rich tradition of kośas. Most of them are arranged as a list of words with similar meaning (synonymic) or a list of words indicating various shades of a given word (polysemic). *Nāmamālā, Śabdaratnākara, Śabdacandrikā* are a few among the first type and *Nānārthasaṅgraha, Anekārthadhvanimañjarī, Viśvaprakāśa* are a few examples of the second type. *Amarakośa, Abhidhānaratnamālā* and *Vaijayantīkośa* has both kind of entries.

This implementation may serve as a model to build similar tools for various other kośas mentioned above.

The *Amarakośa* is now available with various kinds of search facilities as a web service at

http://sanskrit.uohyd.ernet.in/~anusaaraka/sanskrit/samsaadhanii/amarakosha/home.html.

9.2 Future

Amarakośajñānajāla or Knowledge-Net of *Amarakośa* can be used for a variety of Natural Language Processing tasks including information retrieval, semantic tagging, disambiguation, ontologies etc.

Information Retrieval: synonymy relations are used for query expansion to improve the recall of Information Retrieval.

Semantic tagging: It constitutes sense inventory which is the basis for semantic tagging, i.e. texts are tagged with synset identifiers.

Disambiguation: Semantic relationships are used to measure the semantic distance between words, which can be used to disambiguate the meaning of words in texts.

Ontologies: *Amarakośajñānajāla* can be seen as an ontology to be used for a variety of knowledge-based NLP tasks.

Appendix A

WX-notation

This is a roman transliteration scheme for Devanagari.

a	A	i	I	u	U	q	Q	L	e	E	o	O	aM	aH	az
अ	आ	इ	ई	उ	ऊ	ऋ	ॠ	ऌ	ए	ऐ	ओ	औ	अं	अः	अँ

k	K	g	G	f	c	C	j	J	F
क्	ख्	ग्	घ्	ङ्	च्	छ्	ज्	झ्	ञ्
t	T	d	D	N	w	W	x	X	n
ट्	ठ्	ड्	ढ्	ण्	त्	थ्	द्	ध्	न्

p	P	b	B	m
प्	फ्	ब्	भ्	म्

y	r	l	v	S	R	s	h
य्	र्	ल्	व्	श्	ष्	स्	ह्

राम = र्+आ+म्+अ (rAma)

कृष्ण = क्+ऋ+ष्+ण्+अ (kqRNa)

Figure A.1: WX-Notation Chart

Appendix B

Amarakośa and MW comparison result

The gender information of a word from *Amarakośa* given by *Amarasiṁha* is compared with the gender information of the word in Monier William's Sanskrit-English Dictionary. The details of the comparision is given in fourth chapter (4.3). Here genders are marked viz. N, M, and F. Here 'N' indicates neuter gender, 'M' indicates masculine gender and 'F' indicates feminine gender. The result is given in this order Word viz. Amarakośa's gender information, MW's gender information, and MW's reference. In MW's reference page number and column number of the word is given.

B.1 Gender defined by words

Some times *Amarasiṁha* indicates gender by words, but MW is not matching with this. These kind of cases are listed here.

```
Word,Amara_Gender#MW_Gender,Amara_reff,MW_reff_Pg.No._Cl.No.
1) sArasana,N#M,klIbe sArasanaM ca,[p=1209_1]
2) vafkRaNa,M#N,puMsi vafkRaNaH,[p=911_3]
3) yuga,M#N,yAnAxyafge yugaH puMsi,[p=854_1]
4) xiv,F#M,xyoxivO xve swriyAm,[p=478_3]
5) bali,F#M,baliH prANyafgaje swriyAm,[p=723_3]
```

B.2 Gender information from word forms

The gender of the word can be decided from the word endings for some cases, but some of these type of cases also not matching with MW. These kind of cases are listed here.

```
Word,Amara_Gender#MW_Gender,Amara_reff,MW_reff_Pg.No._Cl.No.
1) paviwraka,N#M,SaNasUwraM paviwrakam|,[p=611_1]
2) AlavAla,N#M,syAxAlavAlamAvAlamAvApaH,[p=153_3]
3) AvAla,N#M,syAxAlavAlamAvAlamAvApaH,[p=155_2]
4) upaniRkara,N#M,waw purasyopaniRkaram,[p=201_1]
5) grAmAnwa,N#M,grAmAnwaM upaSalyaM syAw,[p=373_3]
6) kutannata,N#M,kutannataM xASapuraM vAneyaM paripelavaM,[p=288_1]
7) suniRaNNaka,N#M,viwunnam suniRaNNakam,[p=1226_3]
8) apAna,N#M,guxaM wvapAnaM,[p=54_2]
9) alika,N#M,lalAtamalikaM goXiH [p=95_1]
10) sArasana,N#M,waw sArasanamaXikAFgaH,[p=1209_1]
11) kAlapqRTa,N#M,kAlapqRTaM sarAsanam,[p=277_2]
12) prAjana,N#M,prAjanam woxanam wowram,[p=703_2]
13) kaNiSa,N#M,kaNiSam SasyamaFjarI,[p=245_1]
14) puRpakewu,N#M,rIwipuRpaM puRpakewu pORpakaM,[p=639_2]
15) SaSaloman,N#M,SaSorNam SaSalomani,[p=1060_1]
16) kuFjarASana,M#N,pippalaH kuFjarASanaH,[p=288_1]
17) lAkRAprasAxana,M#N,syAwpattI lAkRAprasAxanaH,[p=899_3]
18) sUraNa,M#N,arSoGnaH sUraNaH kanxaH,[p=1243_1]
19) pariGAwana,M#N,pariGaH pariGAwanaH,[p=593_2]
20) wilOxana,M#N,kqsaraswu wilOxanaH,[p=448_2]
21) vasna,M#NF,mUlyam vasnoZpyavakrayaH,[p=931_3]
22) aSmagarBa,M#N,marakawamaSmagarBo harinmaNiH,[p=114_1]
23) suKavarcaka,M#N,kApowaH suKavarcakaH,[p=1221_2]
24) snu,M#FN,snuH prasWaH,[p= 1268_1] [p=1267_3]
25) warxU,M#F,syAwwarxurxAruhaswakaH,[p=440_2]
26) riti,M#F,SqFgI BqFgI ritiswuNdI,[p=880_2]
27) pIwaxAru,N#M,pIwaxAru ca xAru ca,[p=629_3]
28) aheru,F#M,aheruH aWa.....,[p=125_3]
29) SiroXi,F#M,aWa grIvAyAm SiroXiH kaMXarewyapi,[p=1072_3]
```

B.3 Compound words

In some cases of compound words, it is very difficult to decide the gender. For these kind of cases we are following the information from the commentaries. But MW is not matching with these informations. These kind of wors are listed here.

```
Word,Amara_Gender#MW_Gender,Amara_reff,MW_reff_Pg.No._Cl.No.
1) wrixiva,M#NF,svarganAkaswrixivawrixaSAlayAH,[p=458_3]
2) heramba,M#N,apyekaxanwaherambalamboxargajAnanAH,[p=1305_2]
3) jagaccakRus,M#N,jagaccakRurlokabanXuswrayIwanuH,[p=407_3]
4) mAsara,M#N,mAsarAcAmanisrAvA,[p=815_1]
5) vaswa,M#N,swamBacCAgavaswacCAgalakA,[p=932_3]
6) avaxAha,N#M,laGulayamavaxAheRtakApaWe,[p=99_2]
7) avanwisoma,N#M,avanwisomaXAnyAmlakuFjalAni ca kAFjike|,[p=100_3]
8) banXUkapuRpa,M#N,sarjakAsanabanXUkapuRpapriyakajIvakAH,[p=721_2]
9) mAlAwqNaka,N#M,mAlAwqNakaBUswqNe,[p=813_3]
```

Appendix C

Sample Outputs

आजीविका

धीवर

अर्थः :: धीवरः | वर्गः :: वारिवर्गः | कैवर्त, दाश, धीवर, जालिक

आजीविका

अर्थः :: मत्स्यः | वर्गः :: वारिवर्गः | अण्डज, झष, मत्स्य, मीन, पृथुरोमन्, शकुली, वैसारिण, विसार, अनिमिष

Figure C.1: Example of ājīvikā

अवयवी(Holonymy)

अङ्गुली

\> अर्थः :: अङ्गुली | वर्गः :: मनुष्यवर्गः | अङ्गुली, करशाखा, कर्णिका

\>अर्थः :: हस्तः | वर्गः :: मनुष्यवर्गः | पञ्चशाख, पाणि, शय, हस्त, कर

\>अर्थः :: भुजः | वर्गः :: मनुष्यवर्गः | बाहु, भुज, प्रवेष्ट, दोस्

\>अर्थः :: देहः | वर्गः :: मनुष्यवर्गः | गात्र, कलेवर, संहनन, शरीर, वपुस्, वर्ष्मन्, विग्रह, काय, मूर्ति, तनु, तनू, देह, करण, उत्सेध, भूतात्मन्, आत्मन्, धामन्, क्षेत्र, अजिर

Figure C.2: Example of avayvī

अवयवः(Meronymy)

देह

अर्थः :: देहः | वर्गः :: मनुष्यवर्गः | गात्र, कलेवर, संहनन, शरीर, वपुस्, वर्ष्मन्, विग्रह, काय, मूर्ति, तनु, तनू, देह, करण, उत्सेध, भूतात्मन्, आत्मन्, धामन्, क्षेत्र, अजिर

अवयवाः

अर्थः :: चक्षुरादीन्द्रियम् | वर्गः :: धीवर्गः | हृषीक, इन्द्रिय, विषयी, ख
अर्थः :: पाय्वादीन्द्रियम् | वर्गः :: धीवर्गः | कर्मेन्द्रिय
अर्थः :: चक्षुरादीन्द्रियम् | वर्गः :: धीवर्गः | हृषीक, इन्द्रिय, विषयी, ख
अर्थः :: गर्भवेष्टनचर्मः | वर्गः :: मनुष्यवर्गः | गर्भाशय, जरायु
अर्थः :: शुक्लशोणितसम्पातः | वर्गः :: मनुष्यवर्गः | कलल, उल्ब
अर्थः :: कुक्षिस्थगर्भः | वर्गः :: मनुष्यवर्गः | भ्रूण, गर्भ
अर्थः :: कृष्णवर्णदेहगतचिह्नः | वर्गः :: मनुष्यवर्गः | जडुल, कालक, पिप्लु

Figure C.3: Example of avayava

पराजातिः(Hypernymy)

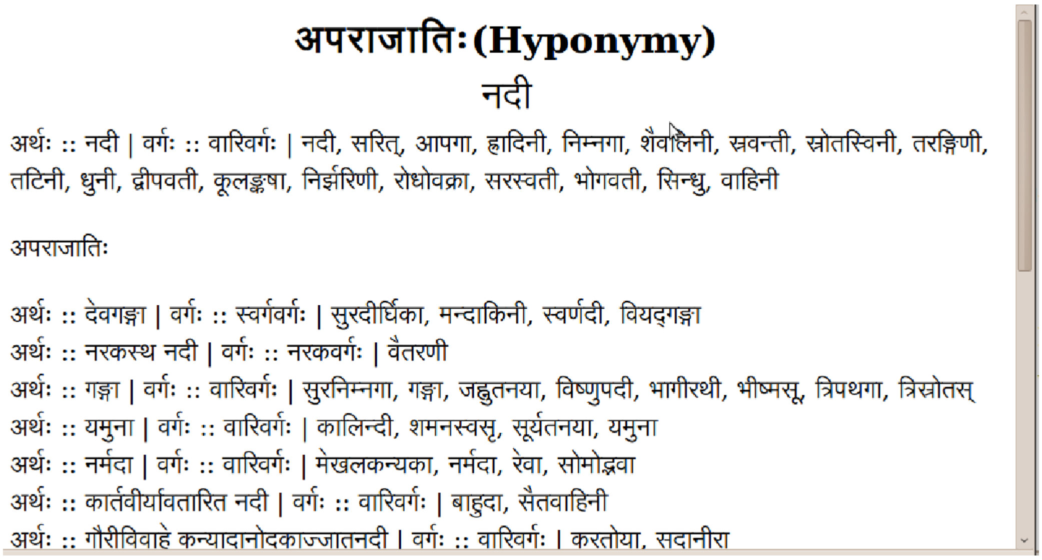
गङ्गा

\>अर्थः :: गङ्गा | वर्गः :: वारिवर्गः | सुरनिम्नगा, गङ्गा, जह्नुतनया, विष्णुपदी, भागीरथी, भीष्मसू, त्रिपथगा, त्रिस्रोतस्

\>अर्थः :: नदी | वर्गः :: वारिवर्गः | नदी, सरित्, आपगा, ह्रादिनी, निम्नगा, शैवलिनी, स्रवन्ती, स्रोतस्विनी, तरङ्गिणी, तटिनी, धुनी, द्वीपवती, कूलङ्कषा, निर्झरिणी, रोधोवक्रा, सरस्वती, भोगवती, सिन्धु, वाहिनी

\>अर्थः :: तटागादयः | वर्गः :: वारिवर्गः | जलाशय, जलाधार

Figure C.4: Example of hypernymy



अपराजातिः (Hyponymy)

नदी

अर्थः :: नदी | वर्गः :: वारिवर्गः | नदी, सरित्, आपगा, ह्रादिनी, निम्नगा, शैवलिनी, स्रवन्ती, स्रोतस्विनी, तरङ्गिणी, तटिनी, धुनी, द्वीपवती, कूलङ्कषा, निर्झरिणी, रोधोवक्रा, सरस्वती, भोगवती, सिन्धु, वाहिनी

अपराजातिः

अर्थः :: देवगङ्गा | वर्गः :: स्वर्गवर्गः | सुरदीर्घिका, मन्दाकिनी, स्वर्णदी, वियद्गङ्गा
अर्थः :: नरकस्थ नदी | वर्गः :: नरकवर्गः | वैतरणी
अर्थः :: गङ्गा | वर्गः :: वारिवर्गः | सुरनिम्नगा, गङ्गा, जह्नुतनया, विष्णुपदी, भागीरथी, भीष्मसू, त्रिपथगा, त्रिस्रोतस्
अर्थः :: यमुना | वर्गः :: वारिवर्गः | कालिन्दी, शमनस्वसृ, सूर्यतनया, यमुना
अर्थः :: नर्मदा | वर्गः :: वारिवर्गः | मेखलकन्यका, नर्मदा, रेवा, सोमोद्भवा
अर्थः :: कार्तवीर्यावतारित नदी | वर्गः :: वारिवर्गः | बाहुदा, सैतवाहिनी
अर्थः :: गौरीविवाहे कन्यादानोदकाज्जातनदी | वर्गः :: वारिवर्गः | करतोया, सदानीरा

Figure C.5: Example of hyponymy

Appendix D

Amarakośa and Hindi WordNet comparison result

Amarakośa Head Word and Hindi WordNet synset ID

svargaH	=	ID 00007040
xevaH	=	ID 00002484
xevayoniH	=	ID 00009157
asuraH	=	ID 00003165
buxXaH	=	ID 00002498
brahmA	=	ID 00002198
viRNuH	=	ID 00002185
vasuxevaH	=	ID 00008010
balaBaxraH	=	ID 00002808
kAmaxevaH	=	ID 00001988
kAmabANaH	=	ID 00021641
aniruxXaH	=	ID 00001003
lakRmI	=	ID 00002959
viRNu-gaxA	=	ID 00014446
viRNu-KadgaH	=	ID 00018860
viRNoH maNiH	=	ID 00007828
viRNu-SafKaH	=	ID 00008194
viRNu-lAFCanam	=	ID 00019349
viRNu-cakram	=	ID 00005103
viRNoH manwriH	=	ID 00001397
viRNoH sAraWiH	=	ID 00021560

garudaH	=	ID 00004434
SivaH	=	ID 00002061
Siva-XanuH	=	ID 00000794
Sivasya jatAbanXaH	=	ID 00020768
pArvawI	=	ID 00002190
sixXiH,1,aNiman,	=	ID 00015156
sixXiH,2,gariman,	=	ID 00022409
sixXiH,3,ISiwva,	=	ID 00022417
sixXiH,4,laGiman,	=	ID 00022411
sixXiH,5,mahiman,	=	ID 00022407
sixXiH,6,prAkAmya,	=	ID 00022415
sixXiH,7,prApwi,	=	ID 00022414
sixXiH,8,vaSiwva,	=	ID 00022419
aNuwAxyaRtaviXapraBAvaH	=	ID 00014078
gaNeSaH	=	ID 00004132
kArwikeyaH	=	ID 00004263
nanxiH	=	ID 00007974
inxraH	=	ID 00002977
inxrapuraH	=	ID 00020982
SacI	=	ID 00008534
inxrasAraWiH	=	ID 00026562
inxravanam	=	ID 00016871
jayanwaH	=	ID 00022894
inxrahaswiH	=	ID 00000964
inxrasya vajrAyuXam	=	ID 00007273
xevarRiH	=	ID 00019549
amqwam	=	ID 00003170
xevagafgA	=	ID 00004872
meruparvawaH	=	ID 00005436
xevavqkRaH	=	ID 00004217
aSvinIkumArO	=	ID 00008023
sanawkumAraH	=	ID 00007575
apsaras	=	ID 00008324
GqwAcInAmApsarA	=	ID 00021001
menakAnAmApsarA	=	ID 00019259
ramBAnAmApsarA	=	ID 00019260
urvaSInAmApsarA	=	ID 00019261
wilowwamAnAmApsarA	=	ID 00021015

hAhAnAmaxevagAyakaH	=	ID 00021363
hUhUnAmaxevagAyakaH	=	ID 00021359
agniH	=	ID 00026468
agnijvAlA	=	ID 00001298
agnikaNaH	=	ID 00001993
Basman	=	ID 00009643
agneH nirgawajvAlA	=	ID 00000511
yamaH	=	ID 00004348
rAkRasaH	=	ID 00003165, ID 00006697
varuNaH	=	ID 00005402
vAyuxevaH	=	ID 00026475
savqRtikaH vAyuH	=	ID 00012308
SarIravAyuH,1,apAna	=	ID 00004968
SarIravAyuH,2,prANa	=	ID 00005361
vegaH	=	ID 00005800
SIGram	=	ID 00002620
avirawam	=	ID 00002868
awiSayaH	=	ID 00002403
kuberaH	=	ID 00008354
kuberapurI	=	ID 00023984
kuberasya uxyAnam	=	ID 00017191
kuberasWAnam	=	ID 00008457
nalakUbaraH	=	ID 00021293
kuberavimAnam	=	ID 00007945
kinnaraH	=	ID 00008644
sAmAnyaniXiH	=	ID 00004595
viSeRaniXiH	=	ID 00013820
AkASaH	=	ID 00002176
xik	=	ID 00003606
xakRiNaxik	=	ID 00006084
pUrvaxik	=	ID 00006898
paScimaxik	=	ID 00006616
xakRiNaxiSAyAH svAmI	=	ID 00020886
uwwaraxik	=	ID 00003776
AgneyaxiggajaH	=	ID 00020884
vAyavyaxiggajaH	=	ID 00020885
ISAnaxiggajaH	=	ID 00022396
suprawIkasya haswinI	=	ID 00022903

agnyAxikoNasya nAma	=	ID 00001312
meGaH	=	ID 00002182
vixyuw	=	ID 00007275
inxraXanus	=	ID 00001017
varRam	=	ID 00006809
jalakaNaH	=	ID 00000429
vAwaprakRipwajalakaNaH	=	ID 00006829
varRopalaH	=	ID 00023532
xivasaH	=	ID 00001965
anwarXAnam	=	ID 00010007
canxraH	=	ID 00026474, ID 00002196
ravicanxrabimbam	=	ID 00012584
canxrasya RodaSAMSaH	=	ID 00001063
KaNdamAwram	=	ID 00001957
nErmalyam	=	ID 00001013
jyowsnA	=	ID 00001062
cihnam	=	ID 00001928
SoBA	=	ID 00005328
paramA SoBA	=	ID 00024404
himam	=	ID 00006826
himasamUhaH	=	ID 00010334
SIwalaxravyam	=	ID 00002597
SEwyam	=	ID 00006828
agaswyaH	=	ID 00014702
lopAmuxrA	=	ID 00021810
XruvaH	=	ID 00026806
pawnI	=	ID 00003057
aSvinI-nakRawram	=	ID 00006914
nakRawram	=	ID 00001234,ID 00000890
uwwaraBAxrapaxA-nakRawram	=	ID 00011299
pUrvaBAxrapaxA-nakRawram	=	ID 00011298
puRya-nakRawram	=	ID 00006984
viSAKA-nakRawram	=	ID 00011289
XaniRTA-nakRawram	=	ID 00011296
mqgaSirA-nakRawram	=	ID 00006964
bqhaspawiH	=	ID 00000227,ID 00004941
mafgalaH	=	ID 00004398
SukrAcAryaH	=	ID 00004223

buXaH	=	ID 00000225
rAhuH	=	ID 00003223
SanIH	=	ID 00026563
sapwarRayaH	=	ID 00010175,ID 00010176
rASInAmuxayaH	=	ID 00007888
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paScAwwApaH	=	ID 00002187
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PaNaH	=	ID 00000758
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SalyaH	=	ID 00001516
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